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Symbols

The following standard symbols are used in Statistics Canada publications:

..	figures not available
...	figures not appropriate or not applicable
-	nil or zero
- -	amount too small to be expressed
e	estimate
p	preliminary figures
r	revised figures
x	confidential to meet secrecy requirements of the *Statistics Act*

Prefixes of the Metric System

Prefix	Abbreviation	Multiplication factor
exa	E	10^{18}
peta	P	10^{15}
tera	T	10^{12}
giga	G	10^{9}
mega	M	10^{6}
kilo	k	10^{3}
hecto	h	10^{2}
deca	da	10^{1}
deci	d	10^{-1}
centi	c	10^{-2}
milli	m	10^{-3}
micro	µ	10^{-6}
nano	n	10^{-9}
pico	p	10^{-12}
femto	f	10^{-15}
atto	a	10^{-18}

Equivalences

1 km^2	=	100 hectares
1 hectare	=	1 km^2 / 100

Abbreviations

A	ampere
Bq	becquerel
cm	centimetre
^oC	degree Celsius
d	day
dB	decibel
g	gram
GWh	gigawatt hour
ha	hectare
h	hour
Hz	hertz
J	joule
kg	kilogram
km	kilometre
km^2	square kilometre
km/h	kilometres per hour
kPa	kilopascal
kt	kilotonne
kV	kilovolt
kWh	kilowatt hour
l	litre
m	metre
m^2	square metre
m^3	cubic metre
Mm^3	million cubic metres
mm	millimetre
mg	milligram
mol	mole
mSv	millisievert
Mt	megatonne
µg	microgram
nec	not elsewhere classified
ng	nanogram
ppm	parts per million
ppb	parts per billion
ppt	parts per trillion
s	second
SIC	Standard Industrial Classification
t	tonne
TJ	terajoule
W	watt

Preface

Canadians recognize the importance of a clean and healthy environment. We understand that the capacity of the environment to supply materials and absorb wastes is finite. But to be effective at reducing our collective impact on the environment we need systematic, accessible and relevant information. Without such information, we are unable to understand and respond to environmental change.

Human Activity and the Environment 2000 meets this need with a collection of environmental statistics, brought together from many sources. The report provides a statistical picture of Canada's environment with special emphasis on human activity and its relationship to natural systems—air, water, soil, plants and animals.

Acknowledgements

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- **Canadian Heritage** (Parks Canada Agency)
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Nunavut—Canada's Newest Territory

On April 1, 1999, the territory of Nunavut was officially established through the *Nunavut Land Claim Agreement.*

Nunavut, formed from parts of the central and eastern Northwest Territories, covers a land area of 1 900 000 km^2. It has a population of approximately 25 000, 84% of whom are of Inuit origin. The largest community is Iqaluit, the capital, with a population of 3 600. Most of Nunavut is located in Arctic ecozones with mean temperatures ranging from -30°C in January to 10°C in July.

As most of the data presented in this publication refer to the period before April 1, 1999, data on the Northwest Territories refer to the **Northwest Territories (including Nunavut), as defined before April 1, 1999**. For reference periods after April 1999, the new administrative boundaries of Nunavut will be incorporated and separate data for Nunavut will be published.

- **Fisheries and Oceans** (Statistical Services, Economic and Policy Analysis Directorate)
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Human Activity and the Environment 2000 on CD-ROM

The CD-ROM included with this report was designed and created by IDON EAST Corporation. It provides additional data and graphics not found in the printed publication, including

- an HTML version of the publication, optimized for Microsoft Internet Explorer version 4 and later;
- Microsoft Excel versions of all data tables and figures, including additional material not found in the printed publication;
- colour graphics and additional colour images;
- a database comprising 37 geo-referenced variables from the Census of Population and Census of Agriculture for the period 1971 to 1996;
- a mapping/graphing tool that can display trends in agriculture and population data using sub-drainage basin and ecozone geographies; and
- a reproduction of the printed *Human Activity and the Environment 2000* publication in portable document format (PDF).

The CD-ROM is found in the plastic pouch attached to the inside back cover of this publication. Complete instructions for the computer installation of the CD-ROM are also found there.

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- **The Household Environment Survey:** Components of this popular survey, including the questionnaire and instructions, are available for use by students. Collect data on the extent to which households are adopting environmentally friendly practices. Compare your results to the provincial and national data from the 1991 and 1994 Household Environment Survey.
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1 Introduction

In the past, we have viewed the environment as an almost limitless source of raw material for our use. We assumed, wrongly, that nature had an equally unlimited ability to absorb waste and would filter any pollution that accompanied our use of these resources. As a result, human activity has had profound impacts on all of the world's natural systems. Many of these impacts are negative and cannot be reversed: for example, unique habitats and plant and animal species cannot be replaced once they are gone.

In the last 50 years, Canada's population has more than doubled and its economic output has increased nearly seven times. To support this growth, we have relied on the environment to supply our increased demand for energy and materials and to absorb a growing amount of waste. In general, the larger our population becomes, the larger our economy and subsequent demand for resources. The implications for the environment are clear: as our population and the economy grow, so does the level of stress we impose on the environment.

The fact that much of Canada's economy is supported by the wealth of its natural resources raises questions about the sustainability of our resource use. Can we maintain air, water and soil quality? Can we continue to extract renewable and non-renewable resources at current rates? Are we implementing conservation and recycling measures?

This edition of *Human Activity and the Environment* provides extensive data on population, economic activities, the environment and the links among these key elements. Analysis and interpretation support the statistics and help readers make sense of these complex interactions.

Organizing Frameworks

Much of the information in *Human Activity and the Environment 2000* is presented by *drainage basin* and *ecozone*.[1] These geographical units provide the reader with a unique opportunity to examine information using boundaries that are not only environmentally relevant but also consistent over time.

The topics in *Human Activity and the Environment 2000* have been deliberately arranged to ensure that data are presented in a meaningful and environmentally relevant fashion.

The book's chapters are grouped in a conceptual framework that illustrates their linkages to each other and their relationship to the book as a whole (Text Box 1.1).

1. A *drainage basin* is an area of land that drains into a single river or ocean. An *ecozone* is a natural region delineated by landform, soil, water, vegetation, climate, wildlife and human factors.

Text Box 1.1

An expanded conceptual framework

Human Activity and the Environment 2000 uses a simple conceptual framework that addresses the complex relationships in human–environment interactions. The chapters and articles in *Human Activity and the Environment 2000* are organized around the key elements in this framework (see Figure 1.1).

The conditions and activities that influence and generate human–environment interactions are **driving forces**. For example, population growth in itself does not affect the environment, but it leads to increased consumption of resources and the generation of wastes. Therefore, the larger a population, the greater its impact on the environment.

As we harvest and consume **natural resources** (e.g., fish, timber and energy), we generate wastes. The resulting pressures placed on our ecosystems can affect human health, demonstrating the close relationship between **ecosystems and well-being**.

As negative environmental changes occur, we seek to reduce our impacts through **responses and participation**. This, in turn, feeds back into the driving forces, as our collective attitude, knowledge and concern for the environment changes.

Organization of the book

Chapters 2 and 3 present the background material required to understand the data in *Human Activity and the Environment 2000*. Chapter 2, **Current Environmental Issues**, provides detailed overviews of four key issues that recur regularly throughout the book. These issues act as both a starting point for the discussion on the environment and a linkage to the various topics discussed in the book. Chapter 3, **Natural Background**, emphasizes the unique and complex nature of Canada's physical features and climate.

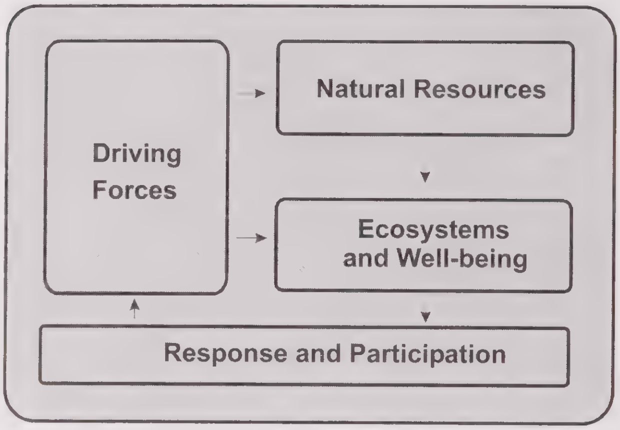
Chapters 4 through 7 address the main components of the framework (Figure 1.1).

- Chapter 4, **Driving Forces**, looks at conditions and trends that shape the relationship between human activities and the environment. This chapter includes background material useful for interpreting the statistics in the rest of the book. Topics covered include population, economic conditions and trends, science and technology, and selected industry profiles.

- Chapter 5, **Natural Resources**, examines one of the main sources of impacts on the environment: the consumption of resources required to maintain or improve our standard of living. This chapter takes a comprehensive look at stocks and uses of our agricultural, forestry, fishery, wildlife, water, energy and mineral resources.
- Chapter 6, **Ecosystems and Well-being**, focusses on issues such as wildlife status and air quality that can have a direct impact on human health and well-being because they affect the health of ecosystems and the environment.
- Chapter 7, **Responses and Participation**, explores the way governments, businesses and households try to respond and adapt as environmental conditions change. This chapter describes activities and practices aimed at minimizing or reducing the harmful effects of human activity on the environment.

A detailed glossary and index conclude the book.

Figure 1.1
Conceptual framework



2 Current Environmental Issues

Introduction

In the last few decades, Canadians have witnessed the emergence of several major environmental concerns. As these unique issues spread beyond local and regional boundaries, addressing them requires the co-operation of many countries.

This chapter examines three international environmental issues—climate change, ozone depletion, and threats to biodiversity. It also examines the concept of sustainable development, which has become, in many ways, the guiding principle by which governments have sought to mitigate or prevent negative impacts of human activity.

Threats to endangered species—among the first global environmental problems to gain international notice—led to the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) in 1974. This was followed by the United Nations Framework Convention on Biological Diversity, which was signed at the Earth Summit in 1992 and is now ratified in over 165 countries (see section 2.4–**Biodiversity**).

The discovery in 1985 of a 'hole' in the ozone layer over the Antarctic also attracted international attention. It led to the 1987 Montréal Protocol, which aims to control the substances that are believed to deplete the ozone layer (see section 2.3–**Stratospheric ozone depletion**). Over 160 countries have ratified this agreement.

The threat of climate change linked to the greenhouse effect has more recently emerged on the political landscape, although it was predicted over a century ago. After the United Nations Framework Convention on Climate Change came the 1997 Kyoto Protocol, whose signatories agreed to control emissions of the gases implicated in the human-induced greenhouse effect (see section 2.2–**Climate change**). The terms of the Kyoto Protocol were accepted by 160 nations.

The impacts of human activities have reached beyond our homes and neighbourhoods; they now affect ecosystems around the globe. An understanding of some of these issues provides an appropriate starting point for our inquiry into human activity and the environment.

Map 2.1
Recent International Agreements to Address Global Environmental Concerns

2.1 Sustainable development

In the 1960s and 1970s, we began to learn that human activities were exceeding the world's ability to deal with the wastes they produced. Prior to this period, the atmosphere seemed too large, the oceans too deep and the forests too vast for our actions to have a significant impact on them. The emergence of global environmental problems such as acid rain, climate change and the hole in the ozone layer changed that perspective and led to calls for a new approach to economic development.

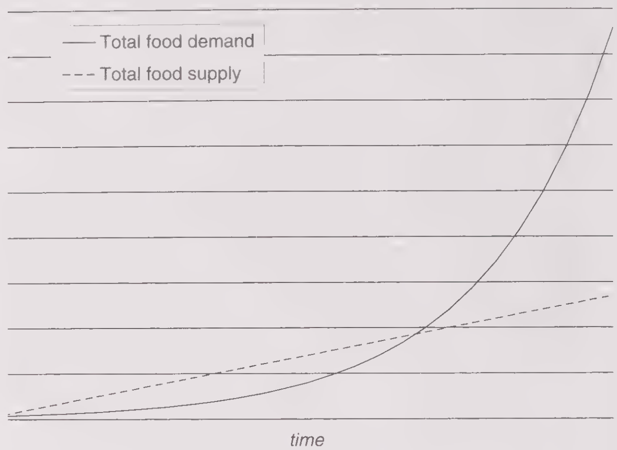
The term 'sustainable development' was popularized in *Our Common Future*, the report of the World Commission on Environment and Development (WCED).[1] The report defined sustainable development as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs."[2]

Evolution of the concept

In 1789, Thomas Malthus published *An Essay on the Principle of Population*. In it, he warned that humanity was about to face a crisis of increasing population. By extension, food consumption would soon surpass the capacity of agricultural production. The basic premise was that since population grows exponentially and agricultural production grows linearly, the demand for food would eventually exceed the available supply of food (Figure 2.1.1). For several reasons, the crisis Malthus predicted did not come to pass, and the term "Malthusian" is used to both describe and dismiss concerns about the balance of population and agricultural production. Regardless of the merits or problems of his argument, Malthus' thoughts represent one of the best-known expressions of the idea that human activity faces natural limits—and that care is needed to ensure that we sustain the conditions necessary for a healthy society.

The Club of Rome's *Limits to Growth*, published in 1972, was among the first modern publications to suggest that human activity is constrained by ecological limits. Following this were the World Conservation Strategy by the International Union for the Conservation of Nature in 1980, the report of the World Commission on Environment and Development in the mid-1980s, the Montréal Protocol to limit ozone-depleting chemicals in 1987, the report of the United Nations Earth Summit in Rio de Janeiro in 1992, and the Kyoto Protocol on climate change in 1997. All of these represent efforts to curb the impact of economic activities on the globe. The term 'sustainable development' has come to epitomize the challenge of managing our economic activities without degrading our environment or society in the process.

Figure 2.1.1
Malthus' Perspective on Population and Agricultural Production



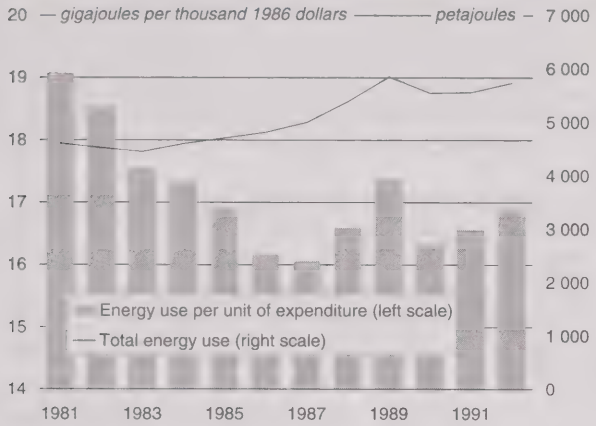
Sustainability, growth and development

A great deal of effort has gone into defining sustainable development.[3] Sustainability itself is a fairly straightforward concept, suggesting that something should last or endure a long time. To understand what it is that we want to sustain, we must turn our attention to the meaning of 'development.'

Development implies improvement or progress. This presents an immediate problem, since progress depends on one's point of view: what appears as a gain to some observers may seem like a loss to others. Modern ideas of progress have focused to a large extent on economic growth. Increases in Gross Domestic Product (GDP) have been commonly viewed as an indication that standards of living are increasing, leading to greater well-being and, by extension, progress.[4] This association of development and economic growth owes its roots in part to former American President Harry Truman who, in his inaugural speech to the U.S. Congress in 1949, described the poor nations of the globe as "underdeveloped," and suggested the need to help them industrialize and follow the economic growth path of the wealthy nations.[5]

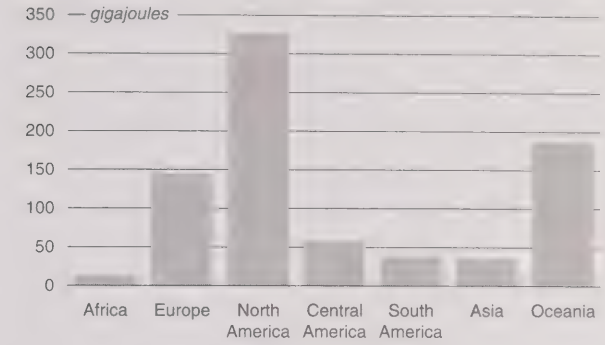
1. The World Commission on Environment and Development was formed by the United Nations in 1983. Its task was to examine the conflicts between environment and development and suggest means of reconciling their differences.
2. World Commission on Environment and Development, 1987, *Our Common Future*, p. 43, Oxford University Press, Oxford.
3. For more details, see: Pearce, D., A. Markandya and E.B. Barbier, 1989, *Blueprint for a Green Economy*, Earthscan Publications, London.
4. For a discussion of the shortcomings of using GDP as a measure of progress, see: Daly, H.E. and J.B. Cobb Jr., 1994, *For the Common Good: Redirecting the Economy toward Community, the Environment, and a Sustainable Future*, Second Edition, pp. 62–84, Beacon Press, Boston.
5. Sachs, W., 1993, "Global Ecology and the Shadow of 'Development'," in W. Sachs (ed.), *Global Ecology: A New Arena of Political Conflict*, pp. 3–21, Zed, London.

Figure 2.1.2
Household Energy Use in Canada, 1981-1992



Source:
Statistics Canada, 1997, *Econnections: Linking the Environment and the Economy—Indicators and Detailed Statistics, 1997*. Catalogue No. 16-200-XKE, Ottawa.

Figure 2.1.3
International Per Capita Energy Consumption, 1995



Source:
World Resources Institute, 1998, *World Resources 1998-99: A Guide to the Global Environment: Environmental Change and Human Health*, World Resources Institute, Washington.

On one hand, the idea of equating development and economic growth is sensible, since money is required to pay for housing, education, health care and other basic needs. On the other hand, growth has led to many of our environmental problems, so more growth may only make our situation worse. The WCED recognized this contradiction and observed that the quality as well as the quantity of growth must be addressed: "Sustainable development involves more than growth. It requires a change in the content of growth, to make it less material- and energy-intensive and more equitable in its impact."[1]

Even this qualified idea of economic growth has come under scrutiny. The problem stems from the fact that economic growth can overcome gains in efficiency, leading to a greater total environmental impact in spite of technological improvements in production. As an example, consider the energy intensity of household consumption. In 1992, Canadian households consumed less energy per $1 000 of expenditures than in the early 1980s, but since we spent more, our total energy use was higher (Figure 2.1.2).

Gradually, our idea of development has broadened from its strict association with economic growth to include environmental and human dimensions. Economic growth remains an important part of the development picture, especially in impoverished countries where basic human needs are still not met, but we now recognize that this growth must be balanced with social and environmental concerns. Managing this balancing act poses several difficulties, since we cannot simply equate social, environmental and economic impacts.[2]

1. World Commission on Environment and Development, 1987, *Our Common Future*, p. 52, Oxford University Press, Oxford.

Global challenges

Sustainable development is clearly a global challenge. In the modern world of free trade, transnational corporations and globalization, sustainability in one country could easily come at the expense of sustainability in another. Conversely, unsustainable activities in one country can have environmental impacts on several nations. The sheer scale of our economic activities contributes to this problem, since environmental impacts have graduated from local to international issues: acid rain, the hole in the ozone layer and climate change do not respect borders.

Although the poor nations of the world were the initial focus of development, it is the wealthy countries whose production and consumption have posed the greatest challenge to sustainability. North America, for example, consumes far more energy on a per capita basis than any other region of the globe (Figure 2.1.3). In a critique of the 1992 Earth Summit, *The Ecologist* summarized the situation in this way:

2. Several countries have undertaken efforts to measure the social and environmental dimensions of sustainability. They have been encouraged by the 1993 revisions to the internationally accepted guidelines for national accounting, which provide details on incorporating environmental information into the national accounting framework. Statistics Canada's *Econnections* series is an example of these efforts. For a more detailed discussion, see: Statistics Canada, 1997, *Econnections: Linking the Environment and the Economy—Concepts, Sources and Methods of the Canadian System of Environmental and Resource Accounts*, Catalogue No. 16-505-GPE, Ottawa.

> "Unwilling to question the desirability of economic growth, the market economy or the development process itself, [the Earth Summit] never had a chance of addressing the real problems of 'environment and development.' Its secretariat provided delegates with materials for a convention on biodiversity but not on free trade; on forests but not on logging; on climate but not on automobiles. Agenda 21—the Summit's 'action plan'—featured clauses on 'enabling the poor to achieve sustainable livelihoods' but none on enabling the rich to do so..."[1]

Observations like this focus attention on the challenges faced when trying to balance the desire to improve standards of living and the need for jobs and economic growth against concerns about environmental quality and social stability.

Key ideas

Several key ideas have emerged during the debate on the meaning of sustainable development. A few of these are summarized below, giving an indication of the concepts that have motivated the idea. For more detail, see the references cited in this section.

Intergenerational equity – This idea is the foundation of the WCED definition of sustainable development, which states that we should not compromise the ability of future generations to meet their needs. Species extinctions, desertification and exhausted mineral reserves, for example, represent lost opportunities for the future.

Living within our means – The idea that natural resources be viewed as money in the bank suggests that we should live off the interest and leave the principal intact. Thus, the rate of natural resource extraction should not exceed the rate of regeneration. Since non-renewable resources do not regenerate, a portion of the profit they earn should be devoted to developing renewable replacements within the lifetime of the resource.

The earth is finite – This relates back to the ideas of Malthus and states that there is a maximum boundary to human activity imposed by the finite nature of the globe, both as a source of natural resources and a sink for our wastes. Indeed, the latter may prove to be the more limiting factor, as evidenced by the problems of pollution, climate change and ozone depletion.

Essential services – Humans rely on several natural cycles that, among other things, absorb wastes, recycle nutrients, protect them from ultraviolet radiation, and provide oxygen and water. It would be neither easy nor desirable for humans to attempt to provide these services themselves should the natural systems begin to fail. This means that there is an absolute minimum degree of ecological integrity that must be maintained to preserve the biosphere.

1. *The Ecologist*, 1993, *Whose Common Future? Reclaiming the Commons*, pp. 1–2, New Society, Philadelphia.

2.2 Climate change

Recent major meteorological events have increased public awareness of the issue of climate change. Although scientists agree that human activity in general is contributing to climate change, their opinions vary on the specifics of this phenomenon.

Causes of warming

The atmosphere surrounding the earth consists almost entirely of nitrogen and oxygen, along with a variety of other gases found in very low concentrations (Table 2.2.1). A certain group of these trace gases is responsible for what has come to be known as the 'greenhouse effect,' which can be briefly explained as follows.

Short-wave solar radiation passes relatively unhindered through the earth's atmosphere to the surface of the planet. Objects on the surface absorb this incoming radiation and are warmed. The warmed objects, in turn, re-emit longer-wavelength (infrared) radiation back into the atmosphere. The earth's atmosphere is less transparent to infrared radiation than it is to short-wave radiation. Trace quantities of water vapour, carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O) and a few other gases absorb some of the outgoing infrared radiation, re-radiating it back to the earth's surface. By preventing a portion of the infrared radiation from escaping to space, these greenhouse gases keep the earth's mean temperature (15°C) about 33°C higher than it would be otherwise.

It is worth noting that the greenhouse effect is a naturally occurring phenomenon. However, there is concern that human-induced changes in the atmospheric concentrations of the greenhouse gases may enhance this natural greenhouse effect. Studies have demonstrated that the atmospheric concentrations of CO_2, CH_4 and N_2O have significantly increased from their pre-industrial values as a result of emissions introduced into the atmosphere by human activity, including a new set of extremely powerful greenhouse gases.[1] Known collectively as the chlorofluorocarbons (CFCs), each of these has thousands of times the ability of CO_2 to absorb infrared radiation.

Evidence of human causes[2]

The link between air temperature and the amount of global atmospheric greenhouse gas present can be seen by analysing air bubbles trapped in Antarctic ice core samples. From these bubbles, scientists have learned that temperature changes over the last 220 000 years seem to be highly correlated with atmospheric concentrations of greenhouse gases. During that time, carbon dioxide concentrations in the atmosphere appear never to have exceeded 300 parts per million (ppm). However, from the time of the Industrial Revolution these concentrations began increasing, from around 280 ppm to over 360 ppm in 1996. About 60% of the increase in CO_2 has occurred since 1958 (Figure 2.2.1), coinciding with the rapid expansion of the fossil fuel-based industrial economy. Furthermore, changes in the mix of carbon isotopes in the atmosphere are characteristic of carbon originating from the burning of fossil fuels and forests.

Correlations do not constitute proof, however, and more evidence is necessary to prove a causal relationship. Global climate models are playing an increasing part in the study of this phenomenon. The first model was developed by the Swedish scientist Arrhenius over 100 years ago, when he established a relationship between greenhouse gases and surface air temperature. His model, although relatively simple, captured the main elements of a very complex system of variables. Today, these are represented by sophisticated models that run on supercomputers. For these models to be credible in predicting the future, it is necessary for them to be able to represent past and present events accurately. These 'general circulation models'

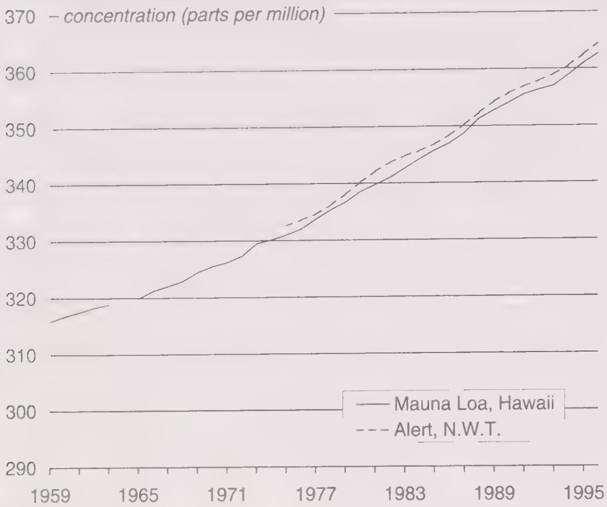
1. Environment Canada, 1996, *The State of Canada's Environment 1996*, Ottawa.
2. The information in this section, except where noted, has been summarized from two sources: Environment Canada, 1996, *The State of Canada's Environment 1996*, Ottawa; and Environment Canada, 1998, *Climate Change*, National Environmental Indicator Series, SOE Bulletin No. 98-3, Ottawa.

Table 2.2.1
Some Characteristics of Key Greenhouse Gases Affected by Human Activities

Greenhouse gas	Pre-industrial concentration	Concentration in 1992	Annual increase in rate of concentration during 1980s	Remarks
CO_2	280 ppmv	335 ppmv	1.5 ppmv (0.4%)	almost entirely of human origin
CH_4	700 ppbv	1 714 ppbv	13 ppbv (0.8%)	natural and human origin
N_2O	275 ppbv	311 ppbv	0.75 ppbv (0.25%)	natural and human origin
CFC-12	0 pptv	503 pptv	18-20 pptv (4%)	entirely human origin
HCFC-22 (a CFC substitute)	0 pptv	105 pptv	7-8 pptv (7%)	human origin; low concentrations now, but rising
CF_4 (a perfluorocarbon)	0 pptv	70 pptv	1.1-1.3 pptv (2%)	human origin; very long lifetime; effectively a permanent atmospheric resident

Notes:
ppmv = parts per million by volume
ppbv = parts per billion by volume
pptv = parts per trillion by volume
Source:
Environment Canada, 1996, *The State of Canada's Environment 1996*, Ottawa.

Figure 2.2.1
Carbon Dioxide Concentrations, 1959-1996

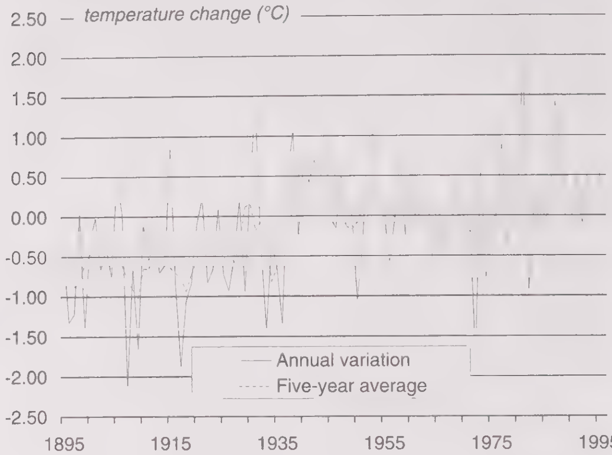


Note:
Data for Mauna Loa, Hawaii, not available for 1964.
Source:
Environment Canada, 1998, *Climate Change*, National Environmental Indicator Series, SOE Bulletin No. 98-3, Ottawa.

predict that a doubling of CO_2 in the atmosphere will result in an increase in the average global surface temperature of between 1.5°C and 4.5°C. It is important, however, to note that this increase will not be uniform geographically or seasonally. The greatest warming would be in the higher latitudes in winter and the least would occur in the tropics. Average global precipitation would increase by 3% to 15%. Sea ice cover and seasonal snow cover in the northern hemisphere would decrease; globally, sea level would rise at an increasing rate.

Analysis of historical data suggests that air temperatures over the world's land areas have warmed, on average, by about 0.5°C over the past century. For regions where long series of data exist, it has been possible to determine that most of the warming has occurred since 1920. Average sea temperature has increased by about 0.4°C. Consistent with the model projections, this warming has been weaker in the tropics and stronger in the middle and high latitudes. The greatest warming has occurred in the continental interiors of the northern hemisphere, whereas the coasts have warmed more slowly or even cooled. In Canada, the northwestern interior has warmed by as much as 1.8°C, whereas the eastern Arctic has cooled over the past 50 years. The average temperature in Canada has increased unevenly over time, with the largest increases occurring from 1920 to 1940 and since 1970 (Figure 2.2.2). Globally, the 10 warmest years since 1860 have all occurred since 1980 (Figure 2.2.3).

Figure 2.2.2
Canadian Temperature Variations, 1895-1996



Source:
Environment Canada, 1998, *Climate Change*, National Environmental Indicator Series, SOE Bulletin No. 98-3, Ottawa.

While most of the observations on climate change are consistent with those projected by climate models, this does not prove that an enhanced greenhouse effect is the cause. This is because the world's average surface temperature since the end of the last ice age has varied over a range of nearly 2°C as a result of purely natural causes.

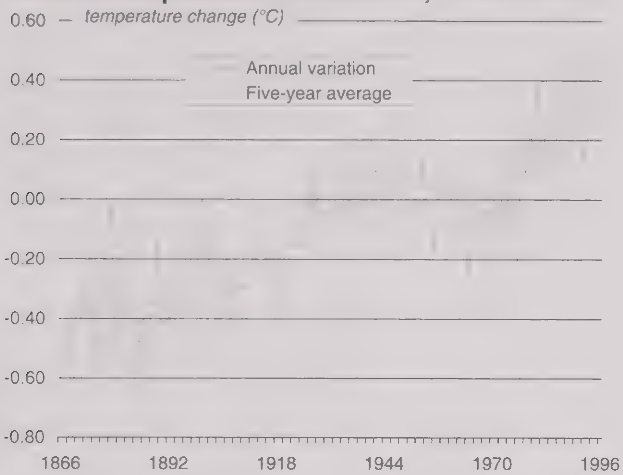
Potential effects of warming on ecosystems

General circulation models (GCMs) used to predict the effects of climate change cannot yet provide reliable results for areas as small as Canada's regions. Confidence in the accuracy of the models is higher for hemispheric or continental projections. Environment Canada states that "confidence in the regional projections is low."[1] This means that although it is very difficult to predict with any accuracy the effects of a doubling in the concentration of greenhouse gases, it is still possible to sketch out the general implications on a regional level. The following effects are considered most likely:

- greater warming of the land than of the sea;
- maximum surface warming in higher latitudes in winter;
- little surface warming over the Arctic in summer;
- an enhanced global mean hydrological cycle; and
- increased precipitation and soil moisture in high latitudes in winter.

1. Environment Canada, 1997, *The Canada Country Study: Climate Impacts and Adaptation. Volume VII: National Sectoral Volume*, Ottawa.

Figure 2.2.3
Global Temperature Variations, 1866-1996



Source:
Environment Canada, 1998, *Climate Change*, National Environmental Indicator Series, SOE Bulletin No. 98-3, Ottawa.

Climate change is expected to lead to an intensification of the global hydrological cycle. This could have major impacts on regional water resources, such as increased annual precipitation in some regions, increased intensity of local precipitation occurrences, and increases in water loss from soil through evaporation and transpiration of plants because of higher air temperatures. In southern Canada, decreases in lake levels, groundwater and soil moisture are predicted while the ice-cover season and the extent of permafrost are expected to decline in the North. For more details on the potential impacts of the climate change in Canada, see *The Canada Country Study.*[1]

Greenhouse gases resulting from human activity

The cause of the increased concentration of greenhouse gases in the atmosphere is human activity, mostly the burning of fossil fuels. See section 6.1–**Waste generation and management** for information on greenhouse gas emissions.

Commitments to reduce greenhouse gases

By ratifying the United Nations Framework Convention on Climate Change in 1992, Canada, along with over 35 other Annex 1 signatory countries, aimed to stabilize its net greenhouse gas emissions at 1990 levels by the year 2000.

On December 11, 1997, 160 countries agreed to the new terms set out in the Kyoto Protocol (Text Box 2.2.1), which aims at reducing the collective emissions of these countries 5.2% from 1990 levels by 2010. Canada's target is a 6% reduction based upon the average emissions from 2008 to 2012. The agreement will take effect after it has been ratified by a minimum of 55 countries whose emissions collectively comprise 55% of the total 1990 emissions from developed countries. The agreement covers emissions of six GHGs. The three most important gases—CO_2, CH_4 and N_2O—will be measured against 1990 levels, whereas the gases with a longer lifetime—hydrofluorocarbons, perfluorocarbons and sulphur hexafluoride—can be measured against 1990 or 1995 levels.

The Kyoto Protocol offers some flexibility in how countries can meet their targets. For example, industrialized countries can receive credit towards their target by financing emission reductions in developing countries. The calculations will also take agriculture, deforestation and the planting of new trees into consideration since these actions have an impact on atmospheric CO_2.

1. Environment Canada, 1997, *The Canada Country Study: National Summary for Policy Makers,* Ottawa, <http://www.ec.gc.ca/climate/ccs/policysummary_e.htm>, (accessed April 9, 1999).

Text Box 2.2.1
Putting the Kyoto Protocol in Context

To put the Kyoto Protocol targets in perspective, it is helpful to examine the relationship between economic growth and the use of fossil fuels—the largest single contribution to greenhouse gas (GHG) emissions. Table 2.2.2 represents a simple model of fossil fuel use in relation to Gross Domestic Product (GDP). Over the last 25 years, the intensity of Canada's fossil fuel use—the ratio of fossil fuel use to GDP—has declined from 18.9 to 13.4 petajoules per billion dollars of GDP. However, the most dramatic decline occurred between 1974 and 1984.

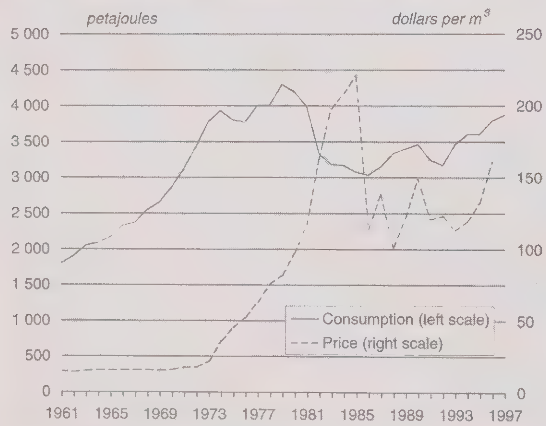
Table 2.2.2
Fossil Fuel Use Necessary to Meet the Kyoto Protocol Targets

Year	GDP	Fossil fuel use	Fossil fuel use intensity	Period	Average annual change: GDP	Average annual change: Fossil fuel use	Average annual change: Fossil fuel use intensity
	billion dollars (1986)	petajoules	petajoules per billion dollars of GDP		percent		
1974	341	6 447	18.91				
1984	467	6 354	13.61	1974-1984	3.2	-0.1	-3.2
1990	566	7 435	13.14	1984-1990	3.3	2.7	-0.6
1995	609	8 132	13.35	1990-1995	1.5	1.8	0.3
2010[1]	819	6 989	8.53	1995-2010	2.0	-1.0	-2.9
2010[2]	949	6 989	7.36	1995-2010	3.0	-1.0	-3.9

Notes:
Targets are met uniformly by a decrease in CO_2 and other greenhouse gases.
The current mix of fuels prevails in the future.
1. Simulation 1: These figures are based on the assumption that the real GDP grows at an annual rate of 2%.
2. Simulation 2: These figures are based on the assumption that the real GDP grows at an annual rate of 3%.
Source:
Statistics Canada, Environment Accounts and Statistics Division.

Projecting a 2% annual growth for GDP from 1995 to 2010, and assuming a fixed relationship between carbon dioxide generation and GDP, the decrease in the intensity of fossil fuel use necessary to meet the Kyoto targets would be about 3% annually. This decrease is almost equivalent to that experienced between 1974 and 1984, a period when crude oil prices increased sharply. If the economy grows at an average rate of 3% until 2010 (Simulation 2 in Table 2.2.2), then the average annual decline in fossil fuel intensity will be 3.9%.

Figure 2.2.4
Oil Prices and Consumption, 1961-1997



Sources:
Statistics Canada and Natural Resources Canada, 1999, *Energy Statistics Handbook*, Catalogue No. 57-601, Ottawa.
Canadian Association of Petroleum Producers.

However, the relationship between economic activity and the emissions of greenhouse gases should not be oversimplified. It is important to emphasize, first, that all economic growth does not require the same amount of energy. Growth in services relative to goods, for example, requires much less energy. A 3% growth rate for the entire economy does not necessarily mean a 3% growth rate for the fossil fuel-intensive sectors. Second, fossil fuel use, although the largest, is not the only source of GHG emissions (see section 6.1–**Waste generation and management**). For the purpose of this illustration, it's assumed that the desired reduction in greenhouse gases is shared proportionally between those generated from fossil fuel combustion and those generated from other sources. Finally, there are a number of different fossil fuels, each with its particular carbon content. For example, for the equivalent amount of energy, the combustion of natural gas releases only 55% as much CO_2 as burning coal does. In the above simulations, it is assumed that this mix remains constant until the year 2010.

The sensitivity of petroleum consumption to petroleum price was especially noticeable between 1974 and 1984 (Figure 2.2.4). The growth in consumption stalled in 1974, after the first oil crisis, and declined after the second oil crisis in 1979. An increase in natural gas consumption compensated for much of the decline. The net effect on greenhouse gas production was favourable, mainly because of the lower carbon content of natural gas. From Table 2.2.2 it can be seen that fossil fuel consumption was slightly lower in 1984 than it was in 1974.

2.3 Stratospheric ozone depletion

Stratospheric ozone[1] is a thin layer of gas situated between 18 and 35 kilometres above the earth's surface. Life on earth has evolved under the protection of this layer, which absorbs most of the sun's harmful radiation.[2] This radiation, especially ultraviolet (UV) radiation in its most energetic form, UV-B, breaks chemical bonds and initiates chemical changes in living cells.

Ozone is not distributed evenly around the globe. It is produced in largest quantities near the equator where sunlight is most direct and intense. Some of that ozone is transported poleward by stratospheric winds. Because of this movement, ozone thickness can be 50% greater at mid and high latitudes than in the tropics. This distribution varies with the seasons. Until recently, the amount of ozone produced in the stratosphere was balanced by the amount destroyed.

Certain chemical compounds manufactured by humans have the ability to destroy stratospheric ozone molecules. These ozone-depleting substances contain chlorine or bromine and are very stable in the lower stratosphere. The most abundant of these is the family of chlorine-based compounds called chlorofluorocarbons (CFCs), which were discovered in 1890. Their effect on the ozone layer was first suspected in the 1960s. Production of CFCs increased dramatically in the 1970s and 1980s. Many new uses were found for them, such as spray propellants, foam-blowing agents, refrigerants, solvents and cleaning agents. Because of their stability, CFCs can last in the atmosphere from several decades to a few centuries. They eventually make their way to the stratosphere where they are broken down by UV radiation, releasing chlorine atoms. Here begins a cycle in which a chlorine atom combines with one of the oxygen atoms from an ozone molecule to form a molecule of chlorine monoxide and a molecule of oxygen. The former breaks down leaving an atom of oxygen, and the chlorine atom is liberated to begin the cycle all over again. Hundreds of thousands of ozone molecules can be destroyed before each chlorine atom stabilizes.

Recent evidence suggests that the warming of the lower atmosphere is resulting in increased destruction of ozone over the Arctic.[3]

Ozone-depleting substances

There are a number of ozone-depleting substances (ODSs), each with a different lifetime and ozone depletion potential (Table 2.3.1). Although production of CFCs is almost halted in developed countries, a large quantity of these compounds is still in use in refrigerators and air conditioners built before alternative refrigerants were available. Hydrochlorofluorocarbons (HCFCs), common substitutes for CFCs, constitute a much lesser threat to the ozone layer. However, HCFCs are also potent greenhouse gases (see section 2.2–**Climate change**).

1. The information in this section, except where noted, has been summarized from the following: Environment Canada, 1996, *The State of Canada's Environment 1996*, Ottawa; and Environment Canada, 1997, *Stratospheric Ozone Depletion*, National Environmental Indicator Series, SOE Bulletin No. 97-2, Ottawa.
2. Ozone also exists at the earth's surface where it is considered a pollutant (see section 6.2–**Air quality**).
3. Warming of the lower atmosphere results in cooling of the stratosphere. The chemical action of chlorine and bromine on ozone is accentuated under colder conditions.

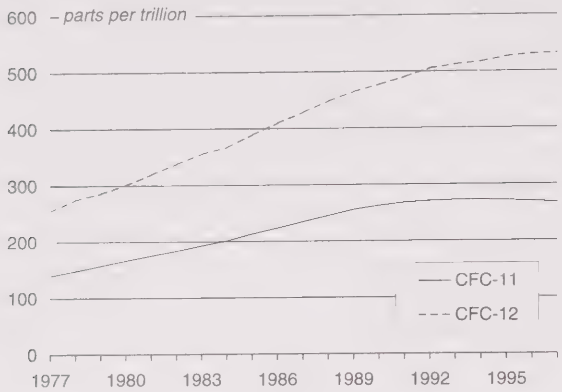
Table 2.3.1
Ozone-depleting Substances

Ozone-depleting substances	Ozone depletion potential range[1]	Canada's phase-out date	Lifetime in atmosphere	Commercial uses
Halons	3.0 to 10.0	January 1, 1994	up to 65 years	fire-extinguishing equipment and systems
Carbon tetrachloride	1.1	January 1, 1995	up to 42 years	CFC production; fire extinguishers; dry cleaning agent; ingredient in pesticides, pharmaceuticals, paints and solvents
CFCs	0.6 to 1.0	January 1, 1996	from 50 to 1 700 years	propellant in aerosols; coolants in refrigerators and air conditioners; solvents in degreasers and cleaners; foam-blowing agent
Methyl chloroform	0.1	January 1, 1996	6 years	solvent in cleaners, degreasers and adhesives
Methyl bromide	0.6	January 1, 2005[2]	up to 2 years	pesticide used in fumigation of soil and of some food production facilities, and in some transportation and quarantine applications related to the export and import of food and other agricultural products
HCFCs[3]	0.001 to 0.52	January 1, 2020	up to 19 years	foam blowing; refrigeration and air conditioning; solvent cleaning; to a lesser extent, aerosols and fire protection

Notes:
1. Each substance has a different effect on the ozone layer that is measured using a standardized reference known as the ozone depletion potential (ODP). For further information, see Environment Canada, 1997, *Stratospheric Ozone Depletion*, National Environmental Indicator Series, SOE Bulletin No. 97-2, Ottawa.
2. Although Canadian Environmental Protection Act ODS regulations currently indicate a phase-out date of January 1, 2010, developed countries party to the Montréal Protocol have agreed to 2005 as the phase-out date for methyl bromide.
3. Most hydrochlorofluorocarbons (HCFCs) have been developed for use as transitional chemicals to replace the more damaging ODSs, mainly CFCs.

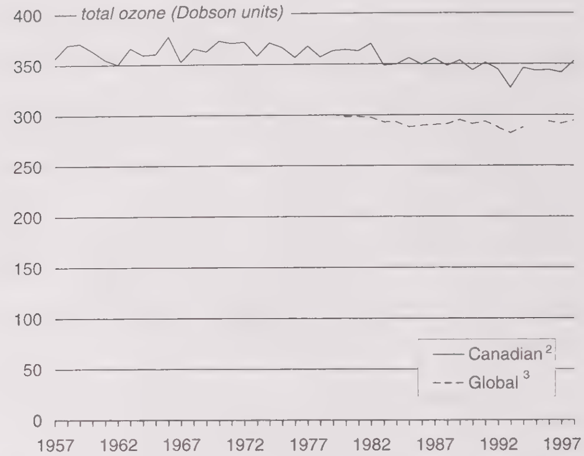
Source:
Auditor General of Canada, 1997, "Ozone Layer Protection: The Unfinished Journey," in *Report of the Auditor General of Canada to the House of Commons*, Chapter 27, <http://www.oag-bvg.gc.ca/domino/reports.nsf/html/ch9727e.html>, (accessed June 14, 1999).

Figure 2.3.1
Global Atmospheric Concentrations of CFC-11 and CFC-12, 1977-1997



Source:
Climate Monitoring and Diagnostics Laboratory (CMDL), National Oceanic and Atmospheric Administration (NOAA), Boulder, Colorado.

Figure 2.3.2
Annual Average Total Ozone for Canada and the World, 1957-1998[1]



Notes:
1. The global level for 1995 is not available because of satellite failure.
2. The Canadian levels are measured from the ground using Brewer Ozone Spectrophotometers.
3. The global levels are measured using the Total Ozone Mapping Spectrometer (TOMS) on the NIMBUS-7 (1979-92), METEOR-3 (1992-93) and Earth Probe (1996-98) satellites.

Sources:
Environment Canada, Atmospheric Environment Service.
Laboratory for Atmospheres, National Aeronautics and Space Administration, Goddard Space Flight Centre, Greenbelt, Maryland.

Global atmospheric concentrations of CFC-11 and CFC-12 (which account for about one-half of the ozone-depleting chlorine entering the stratosphere) were still increasing in the mid-1990s, but their rate of increase dropped after 1989 (Figure 2.3.1). Total CFC levels in the atmosphere were expected to peak by the end of the 1990s and then begin to decline slowly. This relatively slow change in atmospheric CFC concentrations reflects, among other factors, the long lifetimes of the ODSs and the fact that there is still leakage to the atmosphere of ODSs from existing stocks.

The state of the ozone layer

Since 1979, stratospheric ozone has decreased over the entire globe, between 4% and 6% per decade in mid-latitudes and between 10% and 12% per decade in higher southern latitudes (Figure 2.3.2). The levels dropped to record lows following the June 1991 eruption of Mt. Pinatubo in the Philippines. However, the effects of this exceptional event have diminished, as levels returned to values closer to the longer-term downward trend.

Potential effects of ozone depletion

Stratospheric ozone depletion leads to an increase in ultraviolet radiation that reaches the earth's surface. High levels of UV radiation are known to slow plant growth and may lead to skin cancers, cataracts and immunosuppressive diseases in humans and other animals. At mid latitudes (for example, the latitude at which Toronto is located) under clear skies, a 1% decrease in the thickness of the stratospheric ozone layer results in about a 1.1% to 1.4% increase in UV-B at ground level. This varies according to the season. About 200 species of crops and trees in Canada are sensitive to some degree to increased levels of UV-B.

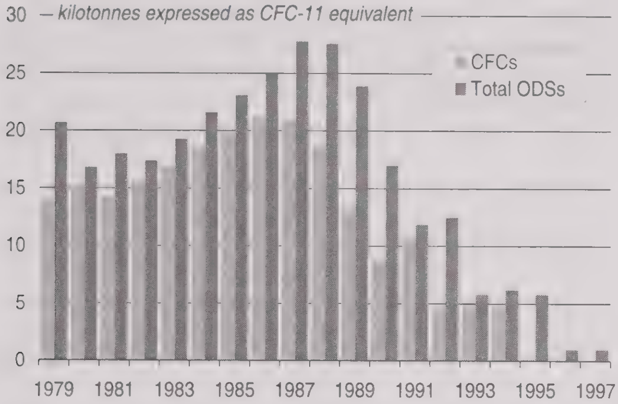
Responses

As one of the original parties to the 1987 Montréal Protocol,[1] Canada has taken a leadership role both in understanding the scientific questions underlying ozone depletion and in acting to eliminate its causes. As shown in Figure 2.3.3, the production of ODSs in Canada has dropped from a high of 27.8 kilotonnes in 1987 to 1.0 kilotonne in 1996. At the global level, 1995 production of CFCs was 77% lower than its peak in 1988. Canada accounted for less than 1% of global production.

Despite this progress, there are still concerns. First, the underlying science cannot yet say with certainty that, even with current ODS-elimination targets, the ozone layer will return to its previous thickness. The concentration of known ODSs in the stratosphere is declining, although there may be other substances that are contributing to ozone

1. The Montréal Protocol (1987), signed by 24 nations, was the first global atmospheric protection agreement to control substances that deplete the ozone layer. By 1997, 162 countries had ratified this agreement to control ODSs.

Figure 2.3.3
Canadian Production of Ozone-depleting Substances, 1979-1997



Source:
Environment Canada, Environmental Protection Service.

depletion.[1] Second, developing countries now represent the largest threat to the recovery of the ozone layer, as their production and use of CFCs has grown in recent years.[2] Third, there is a "loss of momentum" in developed countries, including Canada, because of the perception that the problem has been resolved.[3] The 1997 report of the Auditor General of Canada indicates that current stocks of ODSs, those in existing equipment and quantities stored for future use, are at risk of being released to the atmosphere unless more stringent inspections and safeguards are put in place. The report quotes predictions that destruction of these stocks could improve the recovery of the ozone layer by more than 10%.[4]

1. Wardle, D.I., J. Kerr, C.T. McElroy and D.R. Francis (eds.), *Ozone Science: A Canadian Perspective on the Changing Ozone Layer*, Environment Canada, <http://exp-studies.tor.ec.gc.ca/ozone/Summary97/download.html>, (accessed April 28, 1999).
2. Auditor General of Canada, 1997, "Ozone Layer Protection: The Unfinished Journey," in *Report of the Auditor General of Canada*, Chapter 27, <http://www.oag-bvg.gc.ca/domino/reports.nsf/ch9727e.html>, (accessed June 14, 1999).
3. *Ibid.*
4. *Ibid.*

2.4 Biodiversity

Canada is characterized by large natural tracts of land, diverse landscapes, abundant wildlife and natural resources, and many different ecosystems. In fact, Canada covers over 20% of the world's arctic regions and contains 10% of the forests, 24% of the wetlands and the longest coastline on the planet. Over 9% of the fresh water flowing into the world's oceans originates in Canada.[1]

Canadians have a vested interest in preserving these features and maintaining a rich biodiversity. Our well-being and enjoyment of life is often related to the environment and its biodiversity. Biodiversity is valuable in providing biological, ecological, social and economic benefits on which we depend. The air we breathe, the soil that grows our crops, many of the medicines we take, and the raw materials we use to make industrial products all come from today's diverse environment.

Conceptual definition[2]

Biodiversity, short for biological diversity, refers to the variety of life and its processes. Biodiversity has three descriptive components: species diversity, genetic diversity and ecosystems diversity. The broad nature of this topic encompasses many features of the environment.

Species diversity

Species diversity refers to the variety of organisms in a given area and is a function of species distribution and abundance.[3] Worldwide, there are 1.6 million known species and between 5 million and 100 million unknown species.[4] Species richness—the number of species in a given area—tends to decrease with altitude and from the equator towards northern regions. The harsher physical conditions in the north or at higher altitudes are one of the likely explanations for this trend.[5] Including viruses, there are 71 309 known and an estimated 218 377 unknown species in Canada. Table 2.4.1 presents the number of species for some major groups of organisms in Canada and the world.

1. Environment Canada, 1996, *The State of Canada's Environment 1996*, Ottawa.
2. The information in this section, except where noted, has been summarized from: Mosquin, T., P.G. Whiting and D.E. McAllister, 1995, *Canada's Biodiversity: The Variety of Life, Its Status, Economic Benefits, Conservation Costs and Unmet Needs*, Canadian Centre for Biodiversity, Canadian Museum of Nature, Ottawa.
3. Species diversity is approximatively synonymous with species richness. A more technical definition of species diversity also includes considerations of evenness of species abundances [World Resources Institute, 1992, *Bio-Diversity Glossary of Terms*, <http://www.igc.org/wri/biodiv/gbs-glos.html>, (accessed July 29, 1999)].
4. Environment Canada, *op. cit.*
5. Ricklefs, R.E., 1990, *Ecology*, W.H. Freeman and Company, New York.

Table 2.4.1
Number of Species for Major Groups of Organisms, Canada and the World

	Number of living species			
	Canada		World	
Group of organisms	Known	Estimated[1]	Known	Estimated[1]
Viruses	200	150 000	5 000	500 000
Bacteria	2 400	23 200	4 000	400 000
Fungi	11 310	16 500	70 000	1 000 000
Protozoans	1 000	1 000	40 000	200 000
Algae	5 303	7 300	40 000	200 000
Plants (embryophytes[2])	4 120	4 250	250 000	300 000
Molluscs	1 500	1 635	70 000	200 000
Crustaceans	3 139	4 550	40 000	150 000
Arachnids	3 275	11 006	75 000	750 000
Insects	29 913	54 566	950 000	8 000 000
Vertebrates	1 795	2 310	45 000	50 000
Fish	1 091	1 604	..	..
Amphibians	42	44	..	..
Reptiles	42	42	..	..
Birds	426	426	..	..
Mammals[3]	194	194	..	..

Notes:
1. Includes known and unknown species.
2. The 'higher' plants, or vascular plants.
3. Includes humans.

Sources:
Environment Canada, 1996, *The State of Canada's Environment 1996*, Ottawa.
Mosquin, T., P.G. Whiting and D.E. McAllister, 1995, *Canada's Biodiversity: The Variety of Life, Its Status, Economic Benefits, Conservation Costs and Unmet Needs*, Canadian Center for Biodiversity, Canadian Museum of Nature, Ottawa.

Canada is home to a large variety of species—a reflection of its climatic and geographic diversity—even though species richness is lower in Canada than in many other regions of the world. Canada's biodiversity accounts for species adapted to conditions ranging from very dry to very wet areas, from very hot to very cold temperatures, and from sea bottom to mountain tops. The distribution of known species varies across Canada. Nationally, about 51% of Canada's species are found on land; the rest are located in marine (25%) and freshwater (23%) environments.

Genetic diversity

The variety of genetic information contained in all of the individuals within or among species and populations represents its genetic diversity.[6] This diversity helps the species adapt to and survive stresses such as environmental change and disease. Therefore, the decline in a population's gene pool reduces its capacity to adapt to changes and makes it more susceptible to extinction. Canada has fewer species than equatorial regions have, but these Canadian species are characterized by much larger, more genetically stable populations.

Ecosystem diversity

Ecosystem diversity describes the variety of ecosystems and the diversity of habitats and ecological processes occurring within each ecosystem in a region, in a country and on the planet. An ecosystem is a 'natural neigh-

6. World Resources Institute, 1992, *Biodiversity Glossary of Terms*, <http://www.igc.org/wri/biodiv/gbs-glos.html>, (accessed July 29, 1999).

bourhood' of living and non-living parts, such as plants, animals, soil, rocks and water. Ecosystems vary in size from microscopic to planetary levels, with no fixed boundaries between them; they are open systems. Their stability and health is linked to the stability and health of surrounding ecosystems. Canada's ecosystems are fewer but larger, compared with those of equatorial regions. As with species, ecosystems tend to become less diversified and of greater dimension as you move northward.

Benefits of biodiversity

The variety of life associated with biodiversity provides many benefits. These benefits can be separated into three broad classes: ecosystem services, biological resources and social benefits.[1]

Ecosystem services

Ecosystem services are what organisms and ecosystems do for each other. The various ecosystem interactions between plants, animals and micro-organisms maintain the quality and relative stability of the environment by purifying and regulating air, land and water resources, and by controlling the climate, thus creating conditions that make the planet habitable for all life forms.[2] In fact, ecosystem interactions play a role in the protection of water resources, the formation and protection of soil, the storage and cycling of nutrients, the breakdown and absorption of pollution, the stability of climate, the maintenance of ecosystems' equilibrium, and the recovery of ecosystems from unpredictable events.[3]

Biological resources

Humans make extensive use of biological resources, whose availability depends on biodiversity. Canada's economy was built on natural resources—fishing, trapping, forestry and agriculture. Biological resources like plant and animal species are essential sources of food, medicines and wood products. The availability of these resources is associated with sufficient breeding stocks and population reservoirs and achieved through conservation of biodiversity and healthy ecosystems. Conservation of biodiversity ensures that a wild species gene pool is available to augment the base of established food crops (Text Box 2.4.1).

Text Box 2.4.1

Genetic Diversity in Agriculture

Over 5 000 plant species have been used for food by humans. Many of these species were adapted to human needs and regional conditions through controlled breeding and selection by hundreds of generations of farmers. However, modern agriculture is eroding this genetic legacy by reducing the number of breeders and seed growers.

Since the beginning of this century, as much as three-quarters of the global genetic diversity of agricultural crops has been lost. Also, about a quarter of the breeds of livestock that exist worldwide (around 4 000) are at risk of becoming extinct. Nowadays, only 103 species make up 90% of the world's plant-sourced food supply and less than 20 species feed the majority of the world's population.

In order to conserve plant genes for the future, the United Nations Food and Agriculture Organization formed an international system of gene banks in the 1960s. These are currently maintaining over a million seed samples.

Sources:
Wildfong, B., 1999, "Saving Seeds," *Alternatives Journal*, Vol. 25, No. 1, pp. 12-17.
Australia Department of the Environment, Sport and Territories, Biodiversity Unit, *Biodiversity and its Value*, <http://www.environment.gov.au/life/general_info/op1.html>, (accessed July 23, 1999).

Biological resources are also a source for medicines and a potential source of future medical discoveries. One example is Canada's 134 tree species, of which 38 have one or more recorded medical uses according to Aboriginal, folk or modern medical sources.[4]

Social benefits

Biodiversity shapes our Canadian identity. Our extensive natural areas and the uniqueness and beauty of our diverse ecological systems attract tourists from around the globe and are valued for aesthetic and recreational purposes (see section 7.6–**Recreation**). Ecosystems and biodiversity are an integral part of the life, culture and values of many Canadians. For example, conservation of biodiversity can contribute to conservation of the cultural identity of Aboriginal people.[5] The social cost of biodiversity and ecosystems conservation is often lower than the cost associated with the loss of species or with the rehabilitation of degraded ecosystems.

1. Australia Department of the Environment, Sport and Territories, Biodiversity Unit, *Biodiversity and its Value*, <http://www.environment.gov.au/life/general_info/op1.html>, (accessed July 23, 1999).
2. Keating, M., 1997, *Canada and the State of the Planet: The Social, Economic and Environmental Trends that are Shaping our Lives*, Oxford University Press, Toronto.
3. Australia Department of the Environment, Sport and Territories, *op. cit.*
4. Environment Canada, Canadian Wildlife Service, *Biodiversity*, <http://www.cws-scf.ec.gc.ca/hww-fap/biodiver/biodiv.html>, (accessed July 23, 1999).
5. Australia Department of the Environment, Sport and Territories, *op. cit.*

Human activity and biodiversity

Human activities often have a negative impact on biodiversity. Every day around the globe, species are threatened or extirpated, or become extinct as a consequence of human activities. With so many unknown species, the actual rate at which species are becoming extinct is unclear. In some regions, this rate is believed to be 1 000 to 10 000 times higher than in any other era in the earth's history.[1] If the current extinction rate remains constant, it is estimated that as many as two-thirds of all species will be on the verge of extinction by the end of the 21st century[2] (see section 6.8–**Species at risk**).

Human activities threatening biodiversity can be classified in four categories. First, destruction or alteration of wildlife habitat occurs when natural areas are converted for other uses, such as agriculture and settlement. Second, overexploitation of animal and plant species is the result of unwise gathering or harvesting of biological resources by humans for food, raw materials, medicines and many other purposes. Third, human activities also disturb natural ecosystems by altering their delicate balance. These human disturbances are the result of stresses induced by, for example, the introduction of exotic species (see section 6.9–**Invasive species**) and of pollutants in the air, soil and water (see section 6.5–**Contaminants in biota**). Finally, the monoculture crops advocated by modern agricultural and forestry practices limit the number of species, thereby reducing genetic, species and ecosystem diversity.[3]

Threats to terrestrial and aquatic ecosystems are quite different. Forestry (logging and tree plantations), land conversion by agriculture and urbanization, and pollution cause the highest risks for terrestrial ecosystems. Pollution and the introduction of exotic species have the greatest impact on aquatic ecosystems.[4]

In Canada, human activities have pushed 12 species to extinction; over 327 others have been placed on the vulnerable, threatened, endangered or extirpated species lists[5] (see section 6.8–**Species at risk**). Among Canadian terrestrial ecosystems, those most at risk are located in southern Ontario, in the Prairie provinces and on the West Coast. For example, over 90% of the Carolinian forests have disappeared from southern Ontario, and the West Coast old growth forests are being fragmented; nearly all (99%) of the tallgrass prairie and 80% of the aspen parkland and shortgrass prairie have been altered. In addition, 70% of the Pacific estuary marshes, 70% of the Prairie potholes, 68% of southern Ontario wetlands, and 65% of the Atlantic coastal salt marshes have been converted to human uses. At sea, several Pacific and Atlantic fish populations have been seriously reduced or totally destroyed.[6]

Nations are increasingly recognizing the importance of biodiversity and the long-term negative impact that human activities have on ecosystems (Text Box 2.4.2). Many are taking action to reverse the trends of species extinction and ecosystem disturbance and destruction. International treaties on conservation and the management of biodiversity and illegal trading, *in situ* conservation (e.g., protected areas, restoration and rehabilitation), *ex situ* conservation (e.g., zoos, aquariums and botanical gardens), and sustainable use of biological resources in agriculture, forestry and fishing—all are part of the effort toward conservation of biological diversity.

Text Box 2.4.2
The United Nations Framework Convention on Biological Diversity

The Convention on Biological Diversity, one of three international treaties signed at the United Nations Earth Summit in 1992, has since been ratified by more than 165 countries.

The Convention acknowledges the intrinsic value of biodiversity and its vital importance to the future of evolution and the maintenance of life-sustaining systems of the ecosphere.

The objectives of the Convention are

- the conservation of biological diversity;
- the sustainable use of ecosystems, species and genetic material; and
- the fair and equitable sharing of the benefits arising out of the use of genetic resources.

It stipulates that states have a responsibility to ensure that activities within their jurisdiction or control do not damage areas outside their jurisdiction. The Convention also outlines a host of actions to be undertaken by each of the signatory nations. It is up to each signatory nation to identify directions to pursue, according to its capabilities.

Sources:
Organisation for Economic Co-operation and Development (OECD), 1996, *Saving Biological Diversity: Economic Incentives*, Paris.
United Nations Environment Programme, 1992, *Convention on Biological Diversity*, <http://www.biodiv.org/>, (accessed November 10, 1999).

1. Organisation for Economic Co-operation and Development (OECD), 1996, *Saving Biological Diversity: Economic Incentives*, Paris.
2. Environment Canada, 1996, *The State of Canada's Environment 1996*, Ottawa.
3. Environment Canada, Canadian Environmental Protection Act Archives, *Biodiversity*, Issue Elaboration Paper No. 2, <http://www2.ec.gc.ca/cepa/ip02/e02_00.html>, (accessed July 23, 1999).
4. The International Bank, 1995, *Monitoring Environmental Progress: A Report on Work in Progress*, Environmentally Sustainable Development, U.S.A.
5. Environment Canada, Canadian Wildlife Service, COSEWIC, 1999, *Canadian Species at Risk*, Ottawa.
6. Environment Canada, 1996, *op. cit.*

3 Natural Background

Introduction

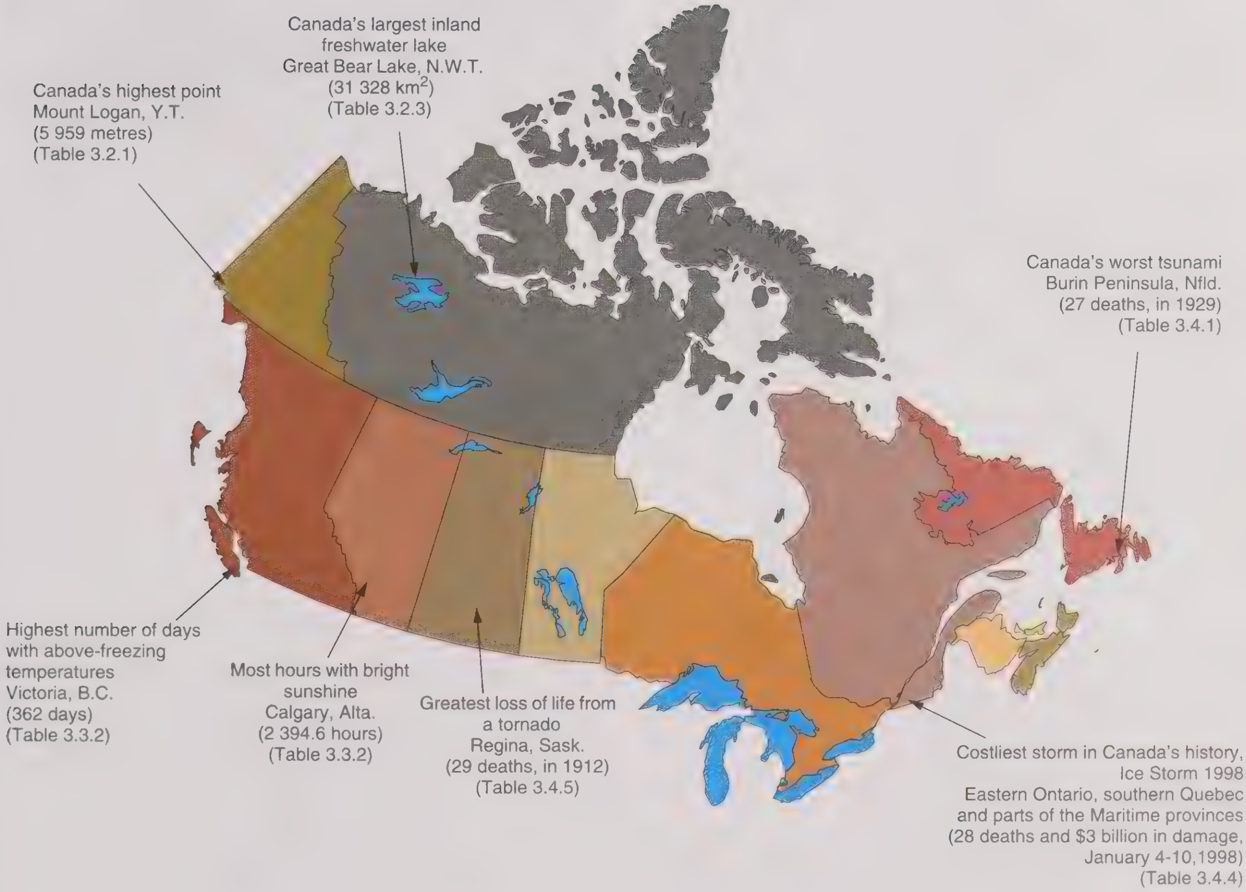
From the mountains in the West, across the central plains, to the rivers and lowlands in the East, and far north to the frozen tundra, Canada's physical environment is vast and varied. This chapter describes the geophysical, meteorological and climatic features of the country's natural background, many of which have an impact on human activity.

Environmental geographies outlines the ecozones and drainage basins used in this book, in conjunction with more conventional political or administrative boundaries, to provide a spatial framework and enhance socio-economic information for environmental analysis.

Physiography and **Climate** present maps and summary tables that examine basic data on Canada's physical geography—relief, land cover, geology, soils, hydrology and wetlands—and normal weather patterns.

Geophysical and meteorological profile is a compendium of natural events—such as earthquakes, storms and floods—that affect Canadians.

Map 3.1
Selected Geophysical, Meteorological and Climatic Extremes



3.1 Environmental geographies

To assess how human populations interact with the natural environment, *Human Activity and the Environment 2000* presents detailed socio-economic data within a consistent spatial framework.

In the past, statistics have been gathered and presented using political or administrative boundaries such as municipalities, counties or provinces. This publication combines typical administrative units with geographical features—environmental geographies—to enhance socio-economic data for environmental analysis.

The two main environmental geographies used in *Human Activity and the Environment 2000* are drainage basins and ecozones.

Drainage basins

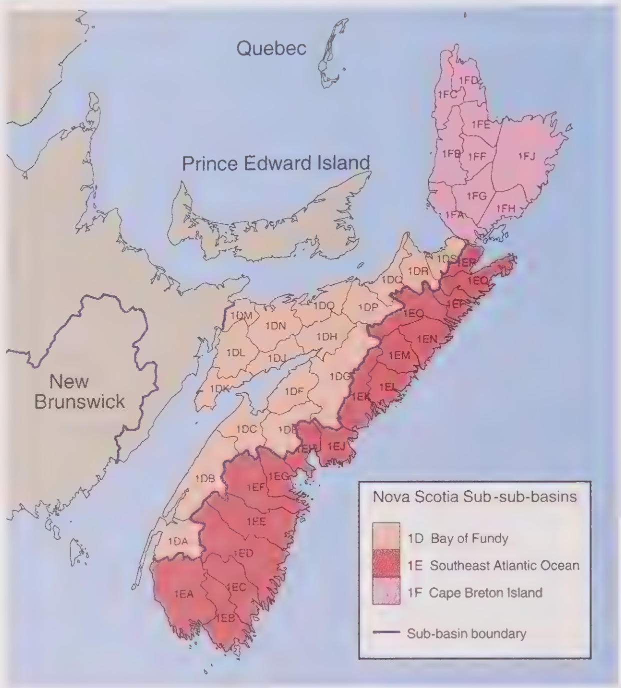
'Drainage basins,' 'watersheds,' 'river basins' and 'river valleys' are terms used to describe a surface drainage catchment area. The boundaries that delineate a drainage basin usually follow heights of land. For example, the ridge of a mountain range can form a drainage basin boundary separating two drainage catchment areas.

Drainage basin boundaries[1] are fixed over time, making them useful for the development and analysis of socio-economic trends. Drainage basins are also valuable environmental stress impact units. For example, human settlements and industries can have many impacts on water systems, affecting the use, discharge and quality of water. The drainage basin classification used in this publication is adapted from the Water Survey of Canada.

Canada is part of the North American continent's hierarchical hydrological system. There are five great basins in Canada. Four of these—the Atlantic Ocean basin, the Hudson Bay basin, the Arctic Ocean basin and the Pacific Ocean basin—encompass a large part of Canada, while the Gulf of Mexico basin covers only a small area of southern Alberta and Saskatchewan.

Map 3.1.1 illustrates the drainage basin hierarchy in the province of Nova Scotia. Map 3.1.2 provides an outline of Canada's five major basins, which are divided into 218 sub-drainage basins. Table 3.1.1 presents sub-drainage basin names and areas. These sub-drainage basins can be further divided into 917 sub-sub-drainage basins.

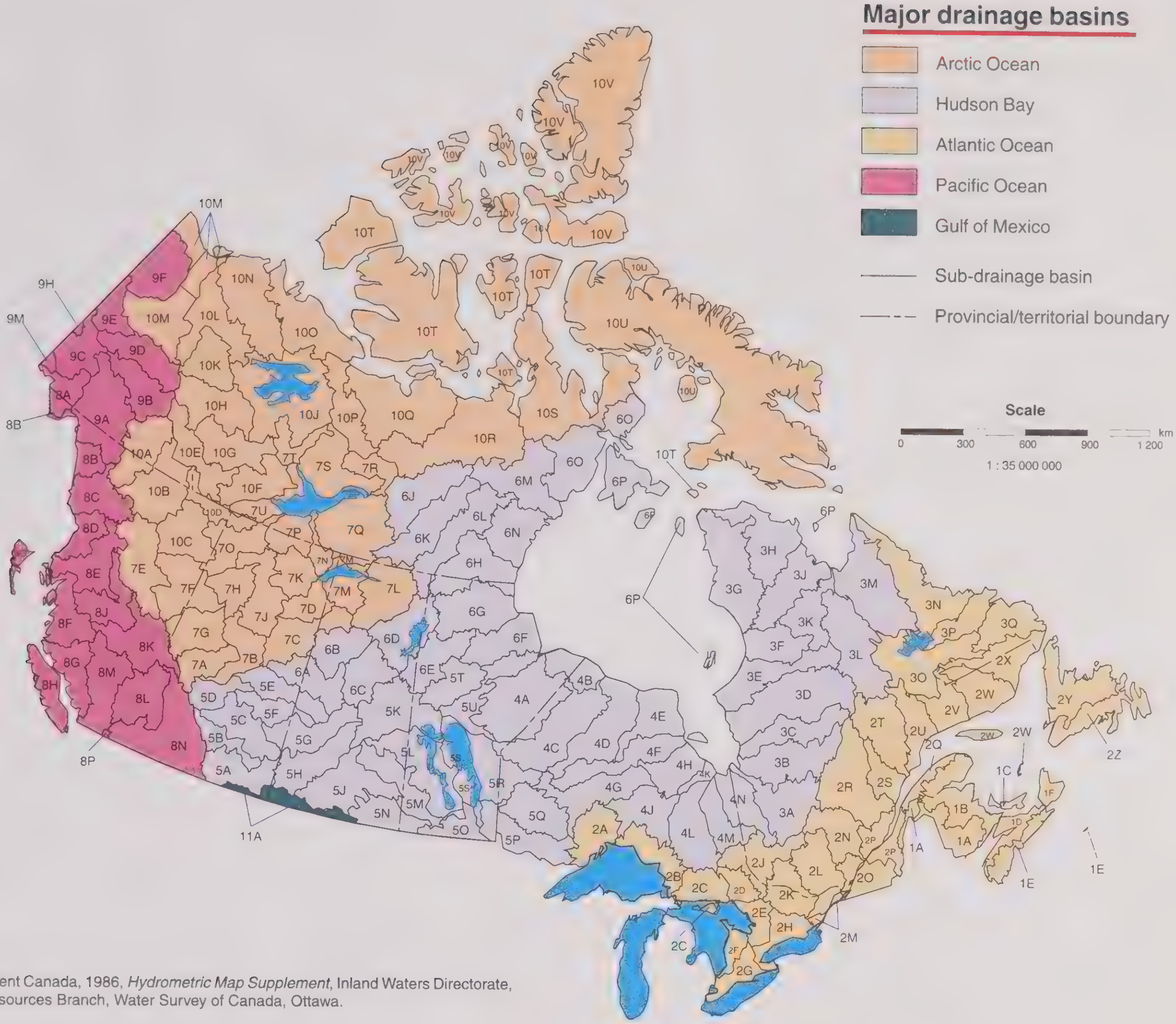
Map 3.1.1
Drainage Basin Hierarchy in Nova Scotia



Source:
Statistics Canada, Environment Accounts and Statistics Division, Environmental Information System.

1. Environment Canada, 1986, *Hydrometric Map Supplement*, Inland Waters Directorate, Water Resources Branch, Water Survey of Canada, Ottawa.

Map 3.1.2
Drainage Basins



Source:
Environment Canada, 1986, *Hydrometric Map Supplement*, Inland Waters Directorate, Water Resources Branch, Water Survey of Canada, Ottawa.

Drainage Basin Areas and Discharges, 1996

Basin	Drainage area	Mean discharge
	km^2	m^3 per second
Arctic Ocean	3 923 403	16 400
Hudson Bay	3 546 429	30 900
Atlantic Ocean	1 399 743	33 400
Pacific Ocean	1 006 147	24 100
Gulf of Mexico	27 585	25

Sources:
Statistics Canada, Environment Accounts and Statistics Division, Environmental Information System.
Fisheries and Environment Canada, 1978, *Hydrological Atlas of Canada*, Catalogue No. En37-26/1978, Ottawa.

Table 3.1.1
Sub-drainage Basin Names and Areas by Province and Territory

Code[1]	Sub-basin code	Province/Territory and sub-basin	Area[2] (km²)
		Newfoundland	
10	2V	Romaine	2 712
10	2W	Natashquan	6 458
10	2X	Little Mecatina and Strait of Belle Isle	25 802
10	2Y	North Newfoundland	65 286
10	2Z	South Newfoundland	45 924
10	3N	North Labrador	88 481
10	3O	Churchill	80 940
10	3P	Naskaupi and Central Labrador	38 490
10	3Q	Eagle and South Labrador	46 915
10		Lakes[3]	9 428
		Total	**410 435**
		Prince Edward Island	
11	1C	Prince Edward Island	5 712
		Total	**5 712**
		Nova Scotia	
12	1D	Bay of Fundy	21 756
12	1E	Southeast Atlantic Ocean	22 772
12	1F	Cape Breton Island	11 823
		Total	**56 352**
		New Brunswick	
13	1A	Saint John and South Bay of Fundy	34 558
13	1B	Gulf of St. Lawrence and North Bay of Fundy	38 684
13	2Q	North Gaspé Peninsula	76
		Total	**73 318**
		Quebec	
24	1A	Saint-Jean	7 055
24	1B	Cascapédia and Gulf of St. Lawrence	21 851
24	2J	Upper Ottawa	33 448
24	2K	Coulonge and Central Ottawa	17 426
24	2L	Gatineau and Lower Ottawa	45 663
24	2M	Upper St. Lawrence	976
24	2N	St-Maurice	43 127
24	2O	Central St. Lawrence	34 772
24	2P	Lower St. Lawrence	37 664
24	2Q	North Gaspé Peninsula	13 932
24	2R	Saguenay	88 048
24	2S	Betsiamites	27 128
24	2T	Manicouagan and Aux Outardes	64 602
24	2U	Moisie and St. Lawrence Estuary	39 588
24	2V	Romaine and Gulf of St. Lawrence	34 309
24	2W	Natashquan and Gulf of St. Lawrence	47 172
24	2X	Little Mecatina	24 694
24	3A	Nottaway	66 914
24	3B	Broadback and Rupert	72 856
24	3C	Eastmain	50 842
24	3D	Fort George and Sakami	114 891
24	3E	Great Whale and Southeast Hudson Bay	65 299
24	3F	Little Whale and East Hudson Bay	44 084
24	3G	Northeast Hudson Bay	101 650
24	3H	West Ungava Bay	75 925
24	3J	Aux Feuilles	64 420
24	3K	Koksoak	44 836
24	3L	Caniapiskau	88 623
24	3M	East Ungava Bay	105 301
24	4M	Abitibi and North French	4 322
24	4N	Harricana	28 723
		Total	**1 510 138**
		Ontario	
35	2A	Nipigon and Northwest Lake Superior	43 812
35	2B	Northeast Lake Superior	40 436
35	2C	North Lake Huron	34 686
35	2D	Wanipitai and French	19 226
35	2E	East Georgian Bay	22 174
35	2F	East Lake Huron	15 056
35	2G	North Lake Erie	23 158
35	2H	Lake Ontario	28 846
35	2J	Montréal and Upper Ottawa	17 807
35	2K	Madawaska, Petawawa and Central Ottawa	23 133
35	2L	Rideau and Lower Ottawa	9 104
35	2M	Upper St. Lawrence	4 463
35	4A	Hayes	16 935
35	4B	Nisksibi and Central Hudson Bay	17 059
35	4C	Severn	90 306
35	4D	Winisk	79 063
35	4E	Ekwan	51 689
35	4F	Attawapiskat	56 661
35	4G	Upper Albany	64 472
35	4H	Lower Albany	39 619
35	4J	Kenogami	51 721
35	4K	Kwataboahegan	8 995
35	4L	Moose	63 948
35	4M	Abitibi	33 044
35	4N	Harricana	15 931
35	5P	Upper Winnipeg	44 102
35	5Q	English	51 946
35	5R	East Lake Winnipeg	21 938
		Total	**989 328**
		Manitoba	
46	4A	Hayes	92 037
46	4B	Nisksibi and Central Hudson Bay	17 457
46	4C	Severn	3 241
46	5J	Qu'Appelle	59
46	5K	Saskatchewan	17 496
46	5L	Lake Winnipegosis and Lake Manitoba	54 836
46	5M	Assiniboine	24 810
46	5N	Souris	9 013
46	5O	Red	25 484
46	5P	Winnipeg	12 913
46	5R	East Lake Winnipeg	33 735
46	5S	West Lake Winnipeg	24 648
46	5T	Rat and Grass	42 304
46	5U	Nelson	47 757
46	6D	Reindeer Lake	10 726
46	6E	Central Churchill	43 284
46	6F	Lower Churchill and West Hudson Bay	54 993
46	6G	Seal and West Hudson Bay	75 309
46	6H	Nueltin Lake	18 802
46	6L	Kazan	859
46		Lakes[3]	40 083
		Total	**649 846**
		Saskatchewan	
47	5A	Upper South Saskatchewan	919
47	5C	Red Deer	197
47	5E	Central North Saskatchewan	13 630
47	5F	Battle	4 455
47	5G	Lower North Saskatchewan	41 336
47	5H	Lower South Saskatchewan	55 305
47	5J	Qu'Appelle	70 565
47	5K	Saskatchewan	58 506
47	5L	Lake Winnipegosis and Lake Manitoba	18 908
47	5M	Assiniboine	27 107
47	5N	Souris	29 598
47	6A	Beaver	32 532
47	6B	Upper Churchill	43 534
47	6C	Upper Central Churchill	45 738
47	6D	Reindeer Lake	48 986
47	6E	Central Churchill	8 130
47	6H	Nueltin Lake	127

Table 3.1.1
Sub-drainage Basin Names and Areas by Province and Territory (continued)

Code[1]	Sub-basin code	Province/Territory and sub-basin	Area[2] (km^2)
47	6L	Kazan	7 837
47	7C	Lower Central Athabasca	14 408
47	7D	Lower Athabasca	2 438
47	7L	Fond du Lac	64 294
47	7M	Athabasca Lake	27 907
47	7Q	Taltson and Southeast Great Slave Lake	4 412
47	11A	Missouri	20 594
47		Lakes[3]	10 769
		Total	**652 233**
		Alberta	
48	5A	Upper South Saskatchewan	45 940
48	5B	Bow	25 453
48	5C	Red Deer	49 152
48	5D	Upper North Saskatchewan	27 968
48	5E	Central North Saskatchewan	28 772
48	5F	Battle	25 710
48	5G	Lower North Saskatchewan	10 752
48	5H	Lower South Saskatchewan	129
48	6A	Beaver	16 997
48	6B	Upper Churchill	695
48	7A	Upper Athabasca	34 902
48	7B	Pembina and Central Athabasca	41 147
48	7C	Lower Central Athabasca	42 308
48	7D	Lower Athabasca	20 055
48	7F	Upper Peace	17 497
48	7G	Smoky	46 141
48	7H	Central Peace	35 742
48	7J	Lower Central Peace	58 748
48	7K	Lower Peace and Lake Claire	36 465
48	7M	Athabasca Lake	11 443
48	7N	Slave	11 580
48	7O	Upper Hay	39 467
48	7P	Buffalo	16 402
48	7Q	Taltson and Southeast Great Slave Lake	1 371
48	7U	West Great Slave Lake	512
48	10C	Fort Nelson	2 224
48	10D	Petitot	1 062
48	11A	Missouri	7 668
48		Lakes[3]	6 991
		Total	**663 291**
		British Columbia	
59	7E	Williston Lake	72 735
59	7F	Upper Peace	49 102
59	7G	Smoky	4 955
59	7O	Upper Hay	8 623
59	7U	West Great Slave Lake	122
59	8A	Alsek	8 317
59	8B	Taku and North Pacific Ocean	22 536
59	8C	Stikine	50 631
59	8D	Nass and North Central Pacific Ocean	29 688
59	8E	Skeena	56 592
59	8F	Gardner Canal and Central Pacific Ocean	55 133
59	8G	Knight Inlet and South Pacific Ocean	43 791
59	8H	Vancouver Island	35 130
59	8J	Nechako	46 855
59	8K	Upper Fraser	65 871
59	8L	Thompson	55 890
59	8M	Fraser	63 082
59	8N	Columbia	102 514
59	8O	Queen Charlotte Islands	10 249
59	8P	Skagit	1 013
59	9A	Upper Yukon	25 210
59	10A	Upper Liard	20 409
59	10B	Central Liard	53 786
59	10C	Fort Nelson	54 027
59	10D	Petitot	14 427
		Total	**950 688**
		Yukon Territory	
60	8A	Alsek	21 464
60	9A	Upper Yukon	67 162
60	9B	Pelly	50 418
60	9C	Upper Central Yukon	44 059
60	9D	Stewart	51 958
60	9E	Central Yukon	29 945
60	9F	Porcupine	62 310
60	9H	Tanana	1 945
60	9M	Mount Logan	4 384
60	10A	Upper Liard	38 597
60	10B	Central Liard	19 327
60	10D	Petitot	2 481
60	10M	Peel and Northwest Arctic Ocean	89 603
		Total	**483 652**
		Northwest Territories	
61	6G	Seal and West Hudson Bay	500
61	6H	Nueltin Lake	54 466
61	6J	Upper Thelon	71 233
61	6K	Dubawnt Lake	70 060
61	6L	Kazan	64 307
61	6M	Lower Thelon	81 132
61	6N	Northwest Central Hudson Bay	59 383
61	6O	Northwest Hudson Bay	97 406
61	6P	Southampton Island	63 086
61	7L	Fond du Lac	5 140
61	7N	Slave	4 917
61	7O	Hay	3 091
61	7P	Buffalo	18 082
61	7Q	Taltson and Southeast Great Slave Lake	90 311
61	7R	Aylmer Lake and MacKay Lake	27 347
61	7S	Yellowknife and Northeast Great Slave Lake	67 390
61	7T	Marian	26 189
61	7U	West Great Slave Lake	28 724
61	10D	Petitot	5 593
61	10E	Lower Liard	52 610
61	10F	Upper Mackenzie	51 082
61	10G	Upper Central Mackenzie	57 514
61	10H	Central Mackenzie	68 073
61	10J	Great Bear	126 786
61	10K	Lower Central Mackenzie	47 458
61	10L	Lower Mackenzie	74 768
61	10M	Peel and Northwest Arctic Ocean	19 019
61	10N	Anderson and West Arctic Ocean	98 692
61	10O	Amundsen Gulf	93 593
61	10P	Coppermine	54 537
61	10Q	Coronation Gulf and Dease Strait	134 077
61	10R	Back and Queen Maud Gulf	159 398
61	10S	Gulf of Boothia	164 028
61	10T	Banks and Victoria Islands	372 175
61	10U	Foxe Basin	556 645
61	10V	Viscount Melville Sound	429 834
61		Lakes[3]	59 666
		Total	**3 458 310**
		Canada total	**9 903 303**

Notes:
1. These are Statistics Canada's codes for provinces and territories.
2. These area figures do not include the area of a number of large freshwater bodies located at the outflow of some basins. The total area of Canada including these is 9 970 610 km^2.
3. "Lakes" in this table refers to those internal lakes shown on Map 3.1.2 (exclusive of the Great Lakes).

Source:
Statistics Canada, Environment Accounts and Statistics Division, Environmental Information System.

Ecozones

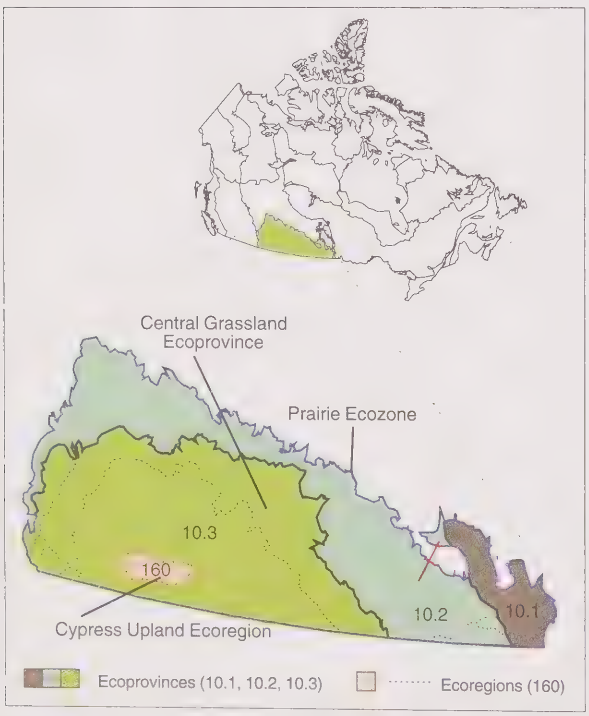
In the early 1970s a need arose to look for a more holistic way of viewing and managing Canada's ecosystems. Ecosystems are distinctive areas where organisms, including humans, and the physical environment (i.e., soils, water, climate) interact as a system. Since ecosystems represent common biophysical characteristics, they are valuable for monitoring the impact of natural and human-sourced stress on the environment and for the analysis of socio-economic information.

The desire for a national approach to ecosystem classification and mapping in Canada led to the development of a hierarchical ecological classification framework. The objective of the approach was to delineate, classify and describe ecologically distinct areas of the earth's surface at different levels of generalization. The ecological framework was developed by identifying distinct areas of non-living (abiotic) and living (biotic) factors that are ecologically related. This hierarchical system ranges from site-specific ecoelements (such as ponds, woodlots and meadows) to broad-level ecozones that encompass large portions of the earth's surface (such as tundra, boreal forests, grasslands and deserts). The framework is designed so that the various orders of ecosystems are related in a hierarchy, in which a lower order ecosystem is nested within a higher order one. From the broadest to the smallest, the hierarchical classification consists of seven levels of generalization: ecozones, ecoprovinces, ecoregions, ecodistricts, ecosections, ecosites and ecoelements.

Mapping ecosystems provides the spatial basis for applying the 'ecosystem perspective'—recognizing the importance of viewing ourselves as part of, rather than separate from, Canada's ecosystems. The hierarchical ecological classification framework divides the country into 20 major ecozones (maps 3.1.4 and 3.1.5).

Brief descriptions of the biophysical characteristics of Canada's 15 terrestrial and 5 marine ecozones are presented in tables 3.1.2 and 3.1.3, respectively. The 15 terrestrial ecozones have been further broken down into 53 ecoprovinces, 194 ecoregions, and 1 021 ecodistricts (Text Box 3.1.1).

Map 3.1.3
Prairie Ecozone with Ecoprovince and Ecoregion Subcomponents



Source:
Ecological Stratification Working Group, 1996, *A National Ecological Framework for Canada*, Agriculture and Agri-Food Canada, Research Branch, Centre for Land and Biological Resources Research and Environment Canada, State of the Environment Directorate, Ecozone Analysis Branch, Ottawa.

Text Box 3.1.1
Mapped Terrestrial Ecozone Ecology Framework Hierarchy

Generalized ↓ Detailed

Ecozone ↓	15 ecozones, representative of large and very generalized ecological units characterized by interactive and adjusting abiotic and biotic factors
Ecoprovince ↓	53 ecoprovinces, characterized by major structural or surface forms, fauna realms, vegetation, soil, hydrology and macroclimate
Ecoregion ↓	194 ecoregions, characterized by distinctive regional ecological factors which include climate, physiography, vegetation, soil, water and fauna
Ecodistrict	1 021 ecodistricts, characterized by distinctive assemblages of relief, fauna, water bodies, soils, landforms and geology

Note:
When this hierarchical approach was extended to mapping, the four levels shown here were deemed to be the most suitable to report on issues of national significance concerning the environment and sustainability of resources.
Source:
Ecological Stratification Working Group, 1996, *A National Ecological Framework for Canada*, Agriculture and Agri-Food Canada, Research Branch, Centre for Land and Biological Resources Research and Environment Canada, State of the Environment Directorate, Ecozone Analysis Branch, Ottawa.

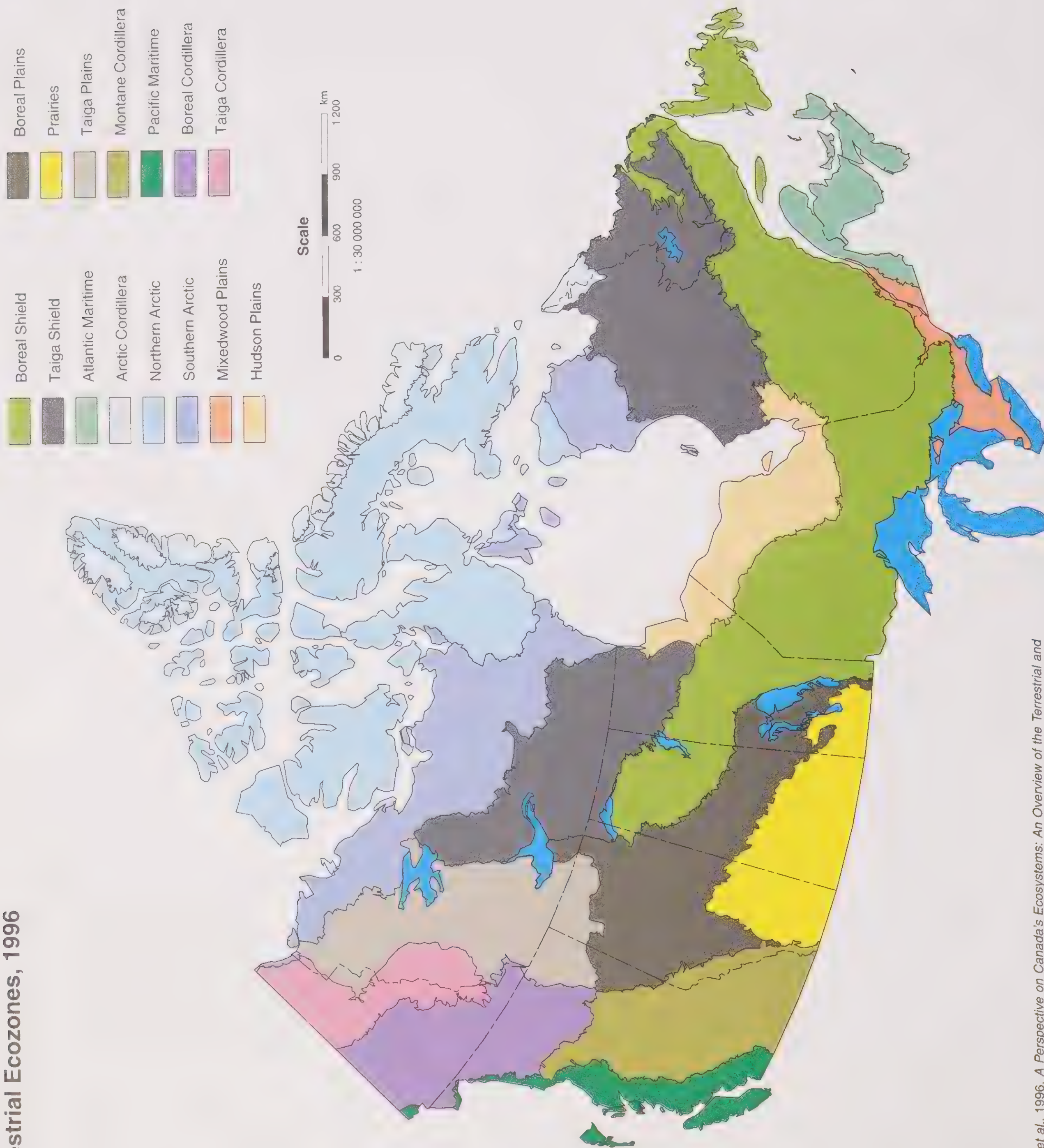
Table 3.1.2
Biophysical Characteristics of Terrestrial Ecozones

Terrestrial ecozone	Land area (km^2)	Landforms	Vegetation/productivity	Surface materials/soils	Climate/oceanographic characteristics
Boreal Shield	1 876 142	plains; some hills	evergreen forest; mixed evergreen-deciduous forest	Canadian Shield rock; moraine; lacustrine; podzols;[1] brunisols[2]	cold; moist
Taiga Shield	1 367 722	plains; some hills	open evergreen-deciduous trees; some lichen-shrub tundra	Canadian Shield rock; moraine; cryosols;[3] brunisols[2]	cold; moist to semi-arid; discontinuous permafrost
Atlantic Maritime	202 619	hills and coastal plains	mixed deciduous-evergreen forest stands	moraine; colluvium; marine; brunisols;[2] podzols;[1] luvisols[4]	cool; wet
Arctic Cordillera	244 584	mountains	mainly unvegetated; some shrub-herb tundra	ice; snow; colluvium; rock; cryosols[3]	extremely cold; dry; continuous permafrost
Northern Arctic	1 529 827	plains; hills	herb-lichen tundra	moraine; rock; marine; cryosols[3]	very cold; dry; continuous permafrost
Southern Arctic	851 673	plains; hills	shrub-herb tundra	moraine; rock; marine; cryosols[3]	cold; dry; continuous permafrost
Mixedwood Plains	113 971	plains; some hills	mixed deciduous-evergreen forest	moraine; marine; rock; luvisols;[4] brunisols[2]	cool to mild; moist
Hudson Plains	374 270	plains	wetlands; some herb-moss-lichen tundra; evergreen forest	organic; marine; cryosols[3]	cold to mild; semiarid; discontinuous permafrost
Boreal Plains	704 719	plains; some foothills	mixed evergreen-deciduous forest	moraine; lacustrine; organic; luvisols;[4] brunisols[2]	cold; moist
Prairies	464 070	plains, some hills	grass; scattered deciduous forest (aspen parkland)	moraine; chernozems[5]	cold; semiarid
Taiga Plains	610 541	plains; some foothills	open to closed mixed evergreen-deciduous forest	organic; moraine; lacustrine; cryosols;[3] brunisols[2]	cold; semiarid to moist; discontinuous permafrost
Montane Cordillera	490 234	mountains; interior plains	evergreen forest; alpine tundra; interior grassland	moraine; colluvium; rock; luvisols;[4] brunisols[2]	moderately cold; moist to arid
Pacific Maritime	213 000	mountains; minor coastal plains	coastal evergreen forest	colluvium; moraine; rock; podzols;[1] brunisols[2]	mild; temperate; very wet to cold alpine
Boreal Cordillera	470 476	mountains; some hills	largely evergreen forest; some tundra; open woodland	colluvium; moraine; rock; podzols;[1] cryosols[3]	moderately cold; moist
Taiga Cordillera	267 283	mountains	shrub-herb-moss-lichen tundra	colluvium; moraine; rock; cryosols;[3] gleysols[6]	very cold winters; cool summers; minimal precipitation

Notes:
1. Podzols are acid and well-weathered soils.
2. Brunisols are soils with minimal weathering.
3. Cryosols are frozen soils.
4. Luvisols are temperate-region soils with clay-rich sublayers.
5. Chernozems are organically rich, relatively fertile grassland soils.
6. Gleysols are soils developed under wet conditions and characterized by reduced iron and other elements.

Sources:
Government of Canada, 1996, *The State of Canada's Environment Part II: Canadian Ecozones*, Minister of Public Works and Government Services Canada, <http://www1.ec.gc.ca/~soer/SOE/default_e.htm>, Ottawa.
Wiken, E.B. *et al.*, 1996, *A Perspective on Canada's Ecosystems: An Overview of the Terrestrial and Marine Ecozones*, Canadian Council on Ecological Areas, Occasional paper, No.14, Ottawa.

Map 3.1.4
Terrestrial Ecozones, 1996



Source:
Wiken, E.B. *et al.*, 1996, *A Perspective on Canada's Ecosystems: An Overview of the Terrestrial and Marine Ecozones*, Canadian Council on Ecological Areas, Occasional paper, No. 14, Ottawa.

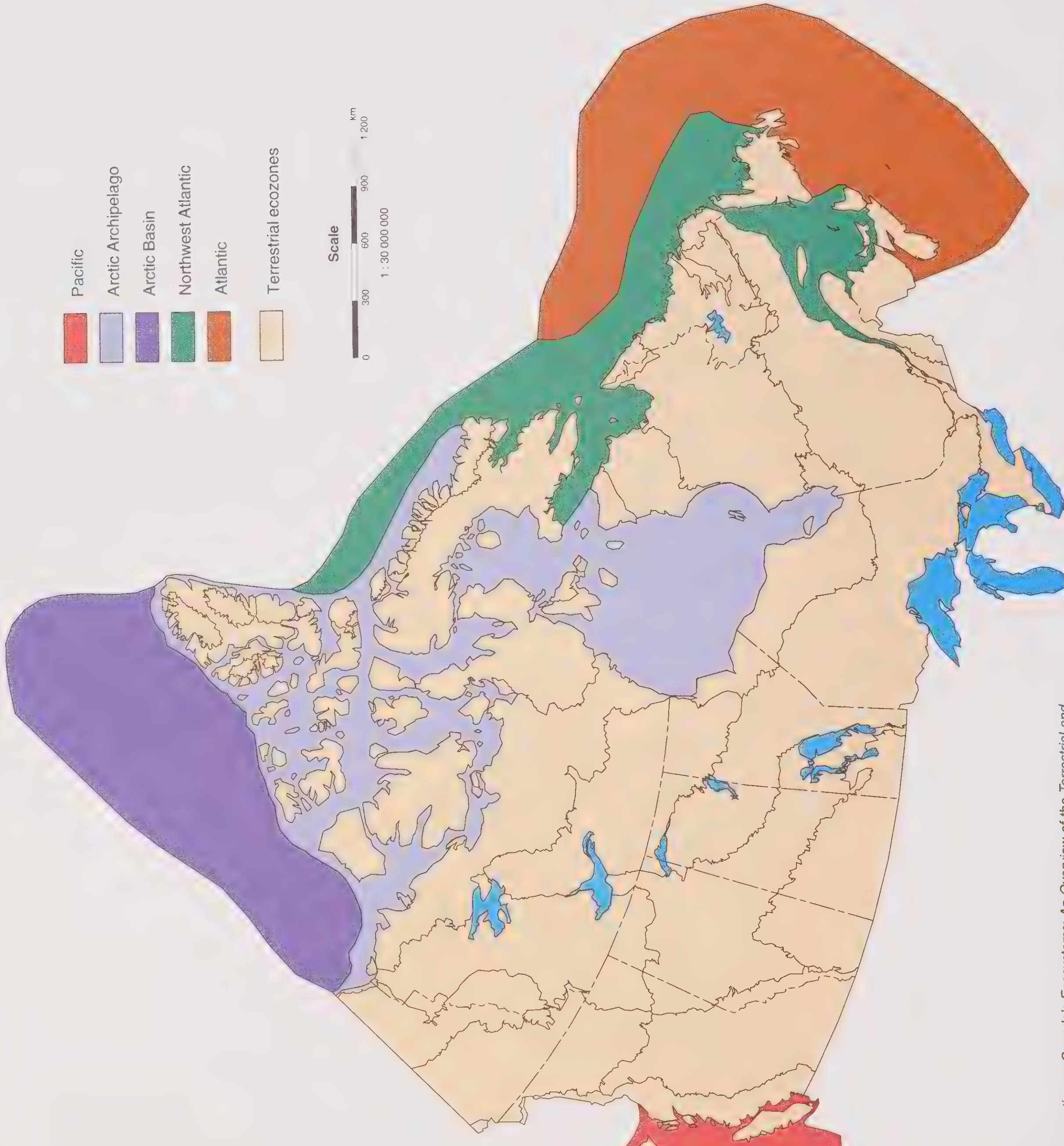
Table 3.1.3
Biophysical Characteristics of Marine Ecozones

Marine ecozone	Landforms	Vegetation/productivity	Surface materials/soils	Climate/oceanographic characteristics
Pacific	Pacific Ocean basin and narrow continental shelf; numerous fjords	one of Canada's most productive areas	generally ice-free, except for local pockets of landfast ice (seasonal)	general eastward-setting oceanic current (Subarctic Current) with divergence point off the shelf; pronounced seasonal upwelling[1] in the south; El Niño influences
Arctic Archipelago	limited to 'shelf-type' depths; high Arctic islands; Arctic and Hudson Bay coasts; much rocky coastline; numerous channels and straits; high coastal relief in east, low in south and west	higher productivity and abundance of life than permanent ice area	seasonal ice; open water 2 to 3 months in summer	relatively high freshwater input along northern continental boundary
Arctic Basin	limited to most northern polar cap areas	low biological productivity and diversity	mainly permanent pack ice	affected by easterly winds driving a clockwise circumpolar gyre[2] in basin; no land components
Northwest Atlantic	primarily continental shelf; generally low coastal relief	strongly influenced by the Labrador Current and Arctic waters	seasonal ice area	Labrador Current exerts strong influence both on shelf and offshore (lower-salinity cold water)
Atlantic	large southern shelf areas (Grand Banks, Scotian Shelf) as well as the Northwest Atlantic basin	very productive area for many species	generally ice-free except for local pockets of landfast ice and, some years, of seasonal ice	includes mostly temperate water masses originating from the south; Gulf Stream offshore and Slope Water Current at the shelf break, mixing zone between cold, lower-salinity water from the north and warmer water from the south

Notes:
1. An upwelling refers to the vertical movement of water, usually near the coast and driven by offshore winds, that brings nutrients from the depths of the ocean to surface layers.
2. A circumpolar gyre is a whirlpool near or around the earth's poles.

Sources:
Government of Canada, 1996, *The State of Canada's Environment Part II: Canadian Ecozones*, Minister of Public Works and Government Services Canada, <http://www1.ec.gc.ca/~soer/SOE/default_e.htm>, (accessed November 30, 1999).
Wiken, E.B. *et al.*, 1996, *A Perspective on Canada's Ecosystems: An Overview of the Terrestrial and Marine Ecozones*, Canadian Council on Ecological Areas, Occasional paper, No.14, Ottawa.

Map 3.1.5
Marine Ecozones



Source:
Wiken, E.B. *et al.*, 1996, *A Perspective on Canada's Ecosystems: An Overview of the Terrestrial and Marine Ecozones*, Canadian Council on Ecological Areas, Occasional paper, No. 14, Ottawa.

3.2 Physiography

Physiography, or physical geography, can be defined as the description of nature or natural phenomena. This section covers some of the key elements that make up Canada's physiography: relief, land cover, surficial geology, soils, hydrology, wetlands and peatlands and organic soils.

Relief

Canada's landscape includes several mountain ranges, including the Torngats, Appalachians and Laurentians in the east; the Rocky, Coastal and Mackenzie ranges in the west; and Mount St. Elias and the Pelly Mountains in the north. At 5 959 metres, Mount Logan in the Yukon Territory is Canada's tallest peak. Table 3.2.1 lists Canada's principal heights by province; Map 3.2.1 illustrates elevation across Canada.

Table 3.2.1
Principal Heights by Province and Territory

Province/Territory[1]	Highest Point	Elevation	Approximate latitude	Approximate longitude
		metres	°N	°W
Yukon Territory	Mount Logan	5 959	60	140
British Columbia	Fairweather Mountain	4 663	58	137
Alberta	Mount Columbia	3 747	52	117
Northwest Territories	Unnamed peak in Mackenzie range	2 773	61	127
Newfoundland	Mount Caubvik[2]	1 652	59	64
Quebec	Mont d'Iberville[2]	1 652	59	64
Saskatchewan	Cypress Hills	1 468	49	110
Manitoba	Baldy Mountain	832	51	101
New Brunswick	Mount Carleton	817	47	67
Ontario	Ishpatina Ridge	693	47	81
Nova Scotia	Cape Breton Highlands	532	46	60
Prince Edward Island	Queen's County	142	46	63

Notes:
1. Provinces and territories are arranged in descending order according to their highest point.
2. Mount Caubvik sits on the Quebec-Labrador border. It is known as Mont d'Iberville in Quebec.
Source:
Natural Resources Canada, Canada Centre for Remote Sensing, GeoAccess.

Land cover

Land cover represents the surface properties of the land. Land cover information is a basic requirement for the determination of land use and, ultimately, of land value. Map 3.2.2 shows the distribution of 12 different land cover types across Canada, including forest and open, developed and non-vegetated land. Land cover types and areas are presented by province and ecozone in Table 3.2.2.

Surficial geology

Surficial geology describes the geologic material that overlays bedrock formations. In Canada, surficial geologic materials typically originate from lacustrine (lake), marine, fluvial (river), and glacial environments. To a lesser extent, alpine, eolian (wind) and volcanic processes contribute to Canada's surficial geology.

Perhaps the best-known and most prominent surficial features in Canada are those left behind by glaciers. Landforms comprising glaciofluvial sediments and glacial tills, such as eskers and drumlins, are evident across a significant portion of Canada's land mass. Map 3.2.3 shows the distribution of surficial materials in Canada, on land and in extensive offshore areas.

Soils

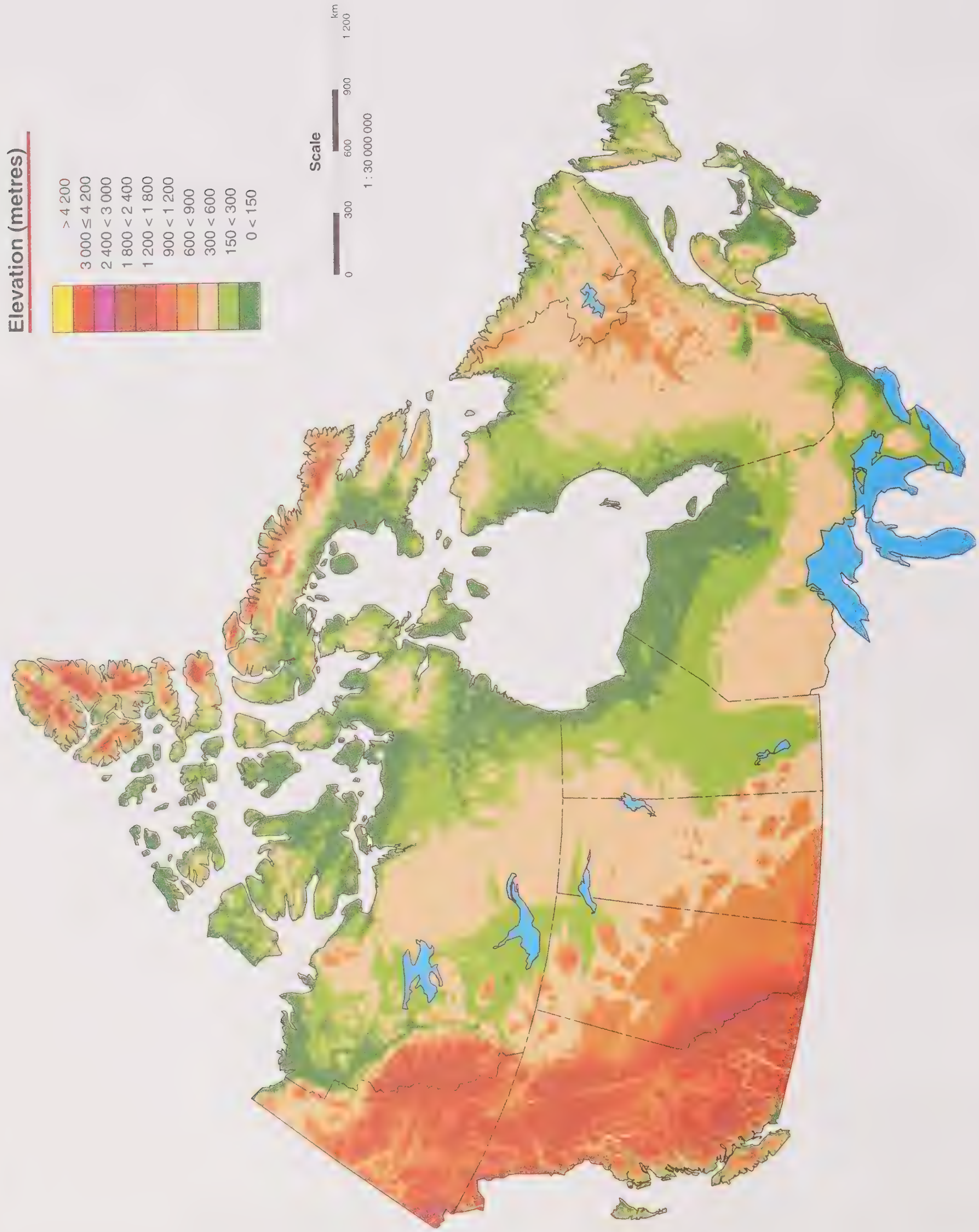
Soil is defined in general terms as "the naturally occurring, unconsolidated mineral or organic material at the earth's surface that is capable of supporting plant growth."[1] Canada's soil classification system is one in which the classes (taxa) are defined on the basis of soil properties, not on interpretation of the soils for various uses. Map 3.2.4 illustrates soil classes at the order level. Taxa at this level are based on properties that reflect the nature of the soil environment and the effects of the dominant soil-forming processes.

Hydrology

There are an estimated two million lakes in Canada, covering approximately 7.6% of Canada's land area.[2] The largest lakes are the Great Lakes, which are shared between the United States and Canada. Other large lakes include Great Bear Lake and Great Slave Lake in the Northwest Territories and Lake Winnipeg in Manitoba. Canada's major lakes, with their depths, elevations and areas, are listed in Table 3.2.3 and illustrated on Map 3.2.5.

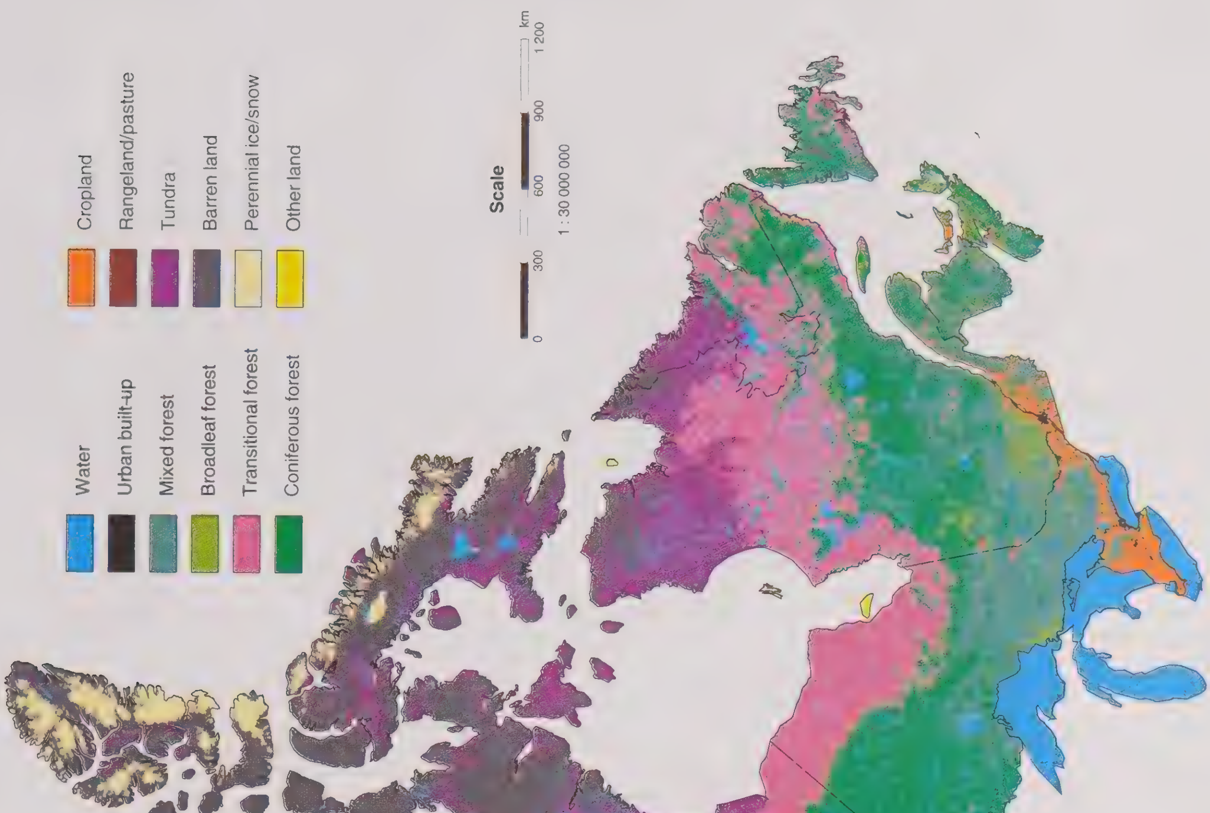
1. Agriculture Canada, Canada Soil Survey Committee, Subcommittee on Soil Classification, 1978, *The Canadian system of soil classification*, Catalogue No. A53-1646/1977, Ottawa.
2. Government of Canada, *Facts on Canada*, <http://infocan.gc.ca/facts/canadagen-e.html>, (accessed July 27, 1999).

Map 3.2.1
Elevation, 1998



Source:
U.S. Geological Survey, EROS Data Center, 1998, Hydro1k Elevation Derivative Database, <http://edcwww.cr.usgs.gov/landdaac/gtopo30/hydro>, Sioux Falls, South Dakota.

Map 3.2.2
Land Cover, 1992



Source:
Natural Resources Canada and Forestry Canada, 1994, "Canada Vegetation Cover," Ottawa (Digital Satellite Image.)

Table 3.2.2
Land Cover by Province, Territory and Ecozone, 1992

Province/Territory and ecozone	Barren land	Broadleaf forest	Coniferous forest	Cropland	Lakes	Mixed forest	Perennial ice/snow	Rangeland/ pasture	Rivers	Transitional forest	Tundra	Urban built-up areas	Other covers	Total
							km²							
Newfoundland	**31 749**	**-**	**111 391**	**-**	**32 772**	**39 726**	**-**	**-**	**3 879**	**123 786**	**61 353**	**308**	**755**	**405 720**
Boreal Shield	11 846	-	60 610	-	7 417	34 942	-	-	1 315	40 823	125	308	395	157 781
Taiga Shield	6 388	-	50 782	-	25 050	4 784	-	-	2 471	82 963	56 534	-	343	229 314
Arctic Cordillera	13 515	-	-	-	305	-	-	-	93	-	4 694	-	18	18 625
Prince Edward Island	**44**	**381**	**791**	**2 904**	**271**	**1 186**	**-**	**-**	**3**	**-**	**-**	**71**	**9**	**5 660**
Atlantic Maritime	44	381	791	2 904	271	1 186	-	-	3	-	-	71	9	5 660
Nova Scotia	**1 070**	**8 399**	**27 011**	**2 670**	**1 961**	**12 969**	**-**	**-**	**177**	**673**	**-**	**397**	**163**	**55 490**
Atlantic Maritime	1 070	8 399	27 011	2 670	1 961	12 969	-	-	177	673	-	397	163	55 490
New Brunswick	**870**	**9 341**	**18 494**	**1 338**	**1 494**	**41 222**	**-**	**-**	**294**	**-**	**-**	**362**	**26**	**73 440**
Atlantic Maritime	870	9 341	18 494	1 338	1 494	41 222	-	-	294	-	-	362	26	73 440
Quebec	**63 929**	**49 533**	**380 168**	**29 960**	**145 875**	**248 412**	**-**	**-**	**14 792**	**352 871**	**251 383**	**3 587**	**170**	**1 540 680**
Boreal Shield	2 063	41 857	315 939	4 930	52 550	195 315	-	-	6 302	49 150	-	482	96	668 684
Taiga Shield	2 264	16	47 969	-	67 761	2 014	-	-	5 594	275 527	127 338	-	21	528 504
Atlantic Maritime	63	6 266	9 154	8 214	701	44 139	-	-	361	-	-	451	8	69 356
Arctic Cordillera	12 169	-	-	-	651	-	-	-	174	-	4 555	-	-	17 549
Northern Arctic	13 565	-	-	-	1 449	-	-	-	398	-	21 388	-	2	36 803
Southern Arctic	33 805	-	-	-	20 328	-	-	-	1 490	218	98 101	-	3	153 945
Mixed Wood Plains	-	1 391	150	16 816	346	6 933	-	-	95	-	-	2 654	38	28 422
Hudson Plains	-	4	6 957	-	2 090	10	-	-	379	27 976	-	-	2	37 418
Ontario	**94**	**22 785**	**337 627**	**54 700**	**145 809**	**258 572**	**-**	**-**	**9 583**	**216 475**	**-**	**5 153**	**17 781**	**1 068 580**
Boreal Shield	66	20 255	307 979	1 393	59 245	238 755	-	-	6 278	12 995	-	134	12 090	659 190
Mixed Wood Plains	29	2 529	339	53 307	80 628	17 881	-	-	193	-	-	5 019	3 436	163 361
Hudson Plains	-	1	29 309	-	5 936	1 936	-	-	3 112	203 480	-	-	2 255	246 029
Manitoba	**213**	**44 570**	**223 529**	**59 441**	**99 715**	**31 405**	**-**	**6 966**	**6 316**	**126 624**	**50 293**	**813**	**64**	**649 950**
Boreal Shield	-	11 951	173 531	966	34 676	19 494	-	-	2 543	8 859	-	1	20	252 042
Taiga Shield	-	-	10 752	-	17 355	36	-	-	1 750	71 467	28 903	-	9	130 273
Southern Arctic	-	-	-	-	116	-	-	-	28	-	1 297	-	3	1 445
Hudson Plains	-	-	696	-	1 939	-	-	-	1 228	46 297	20 092	-	11	70 265
Boreal Plains	97	21 560	38 479	11 789	41 578	11 476	-	509	393	-	-	55	19	125 956
Prairie	117	11 059	70	46 686	4 051	400	-	6 457	373	-	-	757	-	69 970
Saskatchewan	**-**	**27 651**	**212 905**	**210 628**	**59 203**	**45 089**	**-**	**60 691**	**4 198**	**31 141**	**6**	**786**	**32**	**652 330**
Boreal Shield	-	-	133 886	-	36 883	13 163	-	-	2 032	1 077	1	-	30	187 072
Taiga Shield	-	65	5 195	-	7 595	3 125	-	-	556	30 064	5	-	-	46 605
Boreal Plains	-	24 824	73 757	34 654	11 868	28 652	-	2 610	1 122	-	-	101	2	177 590
Prairie	-	2 761	68	175 974	2 857	150	-	58 081	488	-	-	685	-	241 063
Alberta	**14 140**	**94 069**	**180 643**	**126 539**	**18 189**	**145 737**	**379**	**74 893**	**4 235**	**-**	**-**	**2 347**	**19**	**661 190**
Boreal Shield	-	2	3 366	-	2 371	824	-	-	79	-	-	-	3	6 646
Taiga Shield	-	120	5 038	-	910	2 809	-	-	115	-	-	-	-	8 992
Boreal Plains	33	82 785	126 447	33 537	11 792	105 573	-	17 558	2 503	-	-	72	5	380 305
Prairie	-	184	300	92 758	1 597	1 133	-	56 407	795	-	-	2 273	-	155 448
Taiga Plains	-	9 726	25 595	12	1 237	25 437	-	-	536	-	-	-	-	62 543
Montane Cordillera	14 107	1 251	19 896	231	282	9 961	379	928	209	-	-	2	10	47 257
British Columbia	**87 587**	**35 205**	**564 277**	**5 131**	**17 978**	**146 689**	**21 627**	**9 462**	**6 551**	**265**	**51 697**	**1 252**	**80**	**947 800**
Boreal Plains	-	5 651	15 620	3 844	90	13 478	-	-	425	-	-	-	-	39 109
Taiga Plains	3	12 284	17 753	-	1 029	35 814	-	-	594	-	-	-	1	67 477
Montane Cordillera	32 515	13 989	301 783	554	10 659	59 364	2 501	9 462	3 012	-	8 568	161	8	442 576
Pacific Maritime	25 411	933	133 632	733	2 802	23 045	16 702	-	984	265	818	1 091	61	206 476
Boreal Cordillera	29 658	2 348	95 489	-	3 397	14 988	2 424	-	1 536	-	42 311	-	10	192 162
Yukon Territory	**43 358**	**240**	**251 096**	**-**	**8 075**	**8 273**	**14 186**	**-**	**4 127**	**20 139**	**133 937**	**-**	**17**	**483 450**
Southern Arctic	11	-	-	-	132	-	-	-	98	-	4 484	-	4	4 729
Taiga Plains	107	77	12 347	-	435	1 692	-	-	203	1 608	1 818	-	12	18 299
Pacific Maritime	24	-	-	-	-	-	4 440	-	-	-	-	-	-	4 465
Boreal Cordillera	13 799	96	157 196	-	6 107	4 904	9 708	-	2 202	-	79 616	-	1	273 627
Taiga Cordillera	29 417	68	81 554	-	1 401	1 677	38	-	1 625	18 531	48 019	-	-	182 330

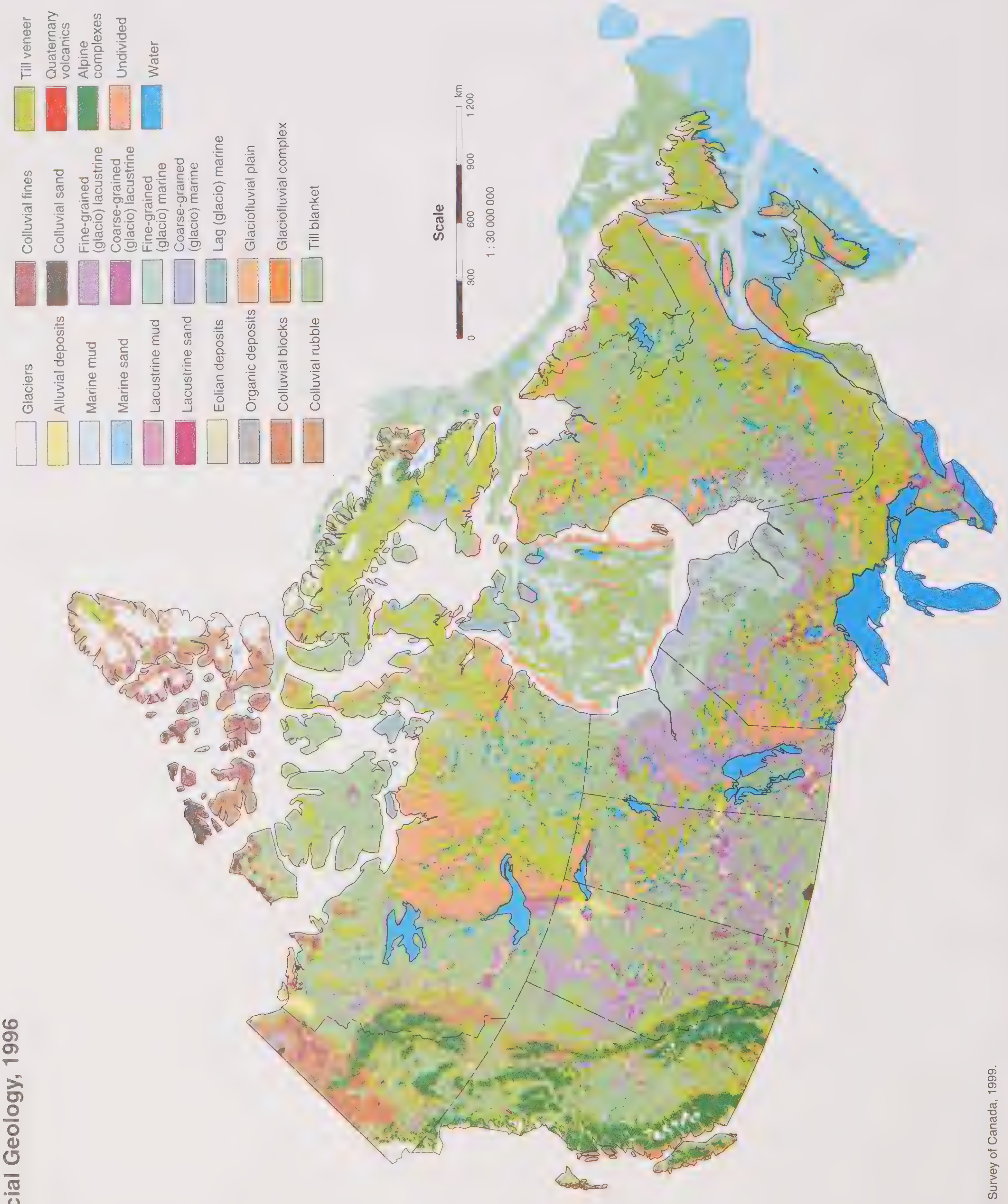
Table 3.2.2
Land Cover by Province, Territory and Ecozone, 1992 (continued)

Province/Territory and ecozone	Barren land	Broadleaf forest	Coniferous forest	Cropland	Lakes	Mixed forest	Perennial ice/snow	Rangeland/ pasture	Rivers	Transitional forest	Tundra	Urban built-up areas	Other covers	Total
								km^2						
Northwest Territories	**1 401 117**	**6 657**	**180 050**	**-**	**321 088**	**114 540**	**156 185**	**-**	**22 282**	**411 789**	**801 126**	**20**	**11 466**	**3 426 320**
Taiga Shield	2 927	1	11 102	-	84 244	3 781	-	-	1 549	223 949	114 791	11	951	443 306
Arctic Cordillera	102 109	-	-	-	1 792	-	111 375	-	772	-	3 817	-	410	220 275
Northern Arctic	1 015 916	-	-	-	82 784	-	44 810	-	12 401	-	307 353	5	2 761	1 466 029
Southern Arctic	232 885	1	941	-	77 906	16	-	-	2 310	36 189	329 377	-	3 988	683 615
Hudson Plains	-	-	-	-	43	-	-	-	7	-	-	-	3 317	3 367
Boreal Plains	1	409	4 022	-	1 137	9 598	-	-	115	817	-	-	-	16 099
Taiga Plains	6 368	5 477	145 254	-	72 999	99 860	-	-	4 529	150 779	19 549	4	36	504 854
Boreal Cordillera	113	16	3 111	-	7	737	-	-	21	-	590	-	-	4 596
Taiga Cordillera	40 796	754	15 620	-	176	549	-	-	579	55	25 649	-	3	84 181
Canada	**1 644 172**	**298 831**	**2 487 983**	**493 309**	**852 431**	**1 093 821**	**192 378**	**152 011**	**76 437**	**1 283 764**	**1 349 795**	**15 096**	**30 580**	**9 970 610**

Note:
Data in this table are compiled from four sources. Land cover types, with the exception of rivers, lakes and urban built-up areas, are from satellite imagery that has a maximum resolution of 1 km^2. Small pockets of cropland may not be apparent at this resolution. Rivers and lakes are from "Digital Chart of the World," while urban built-up areas are from Statistics Canada's digital enumeration area files. The ecozone delineations are from the Ecological Stratification Working Group. Ecozone totals vary slightly from figures published by the Ecological Stratification Working Group because of varying resolution of the source maps.

Sources:
Environmental Systems Research Institute, 1993, "Digital Chart of the World," Redlands, California. (Map.)
Ecological Stratification Working Group, 1996, *A National Ecological Framework for Canada*, Agriculture and Agri-Food Canada, Research Branch, Centre for Land and Biological Resources Research and Environment Canada, State of the Environment Directorate, Ecozone Analysis Branch, Ottawa.
Natural Resources Canada and Forestry Canada, 1994, "Canada Vegetation Cover," Ottawa. (Digital Satellite Image.)
Statistics Canada, 1991, Digital Enumeration Area Polygon File for the 1991 Census of Canada, Geography Division, Ottawa.

Map 3.2.3
Surficial Geology, 1996

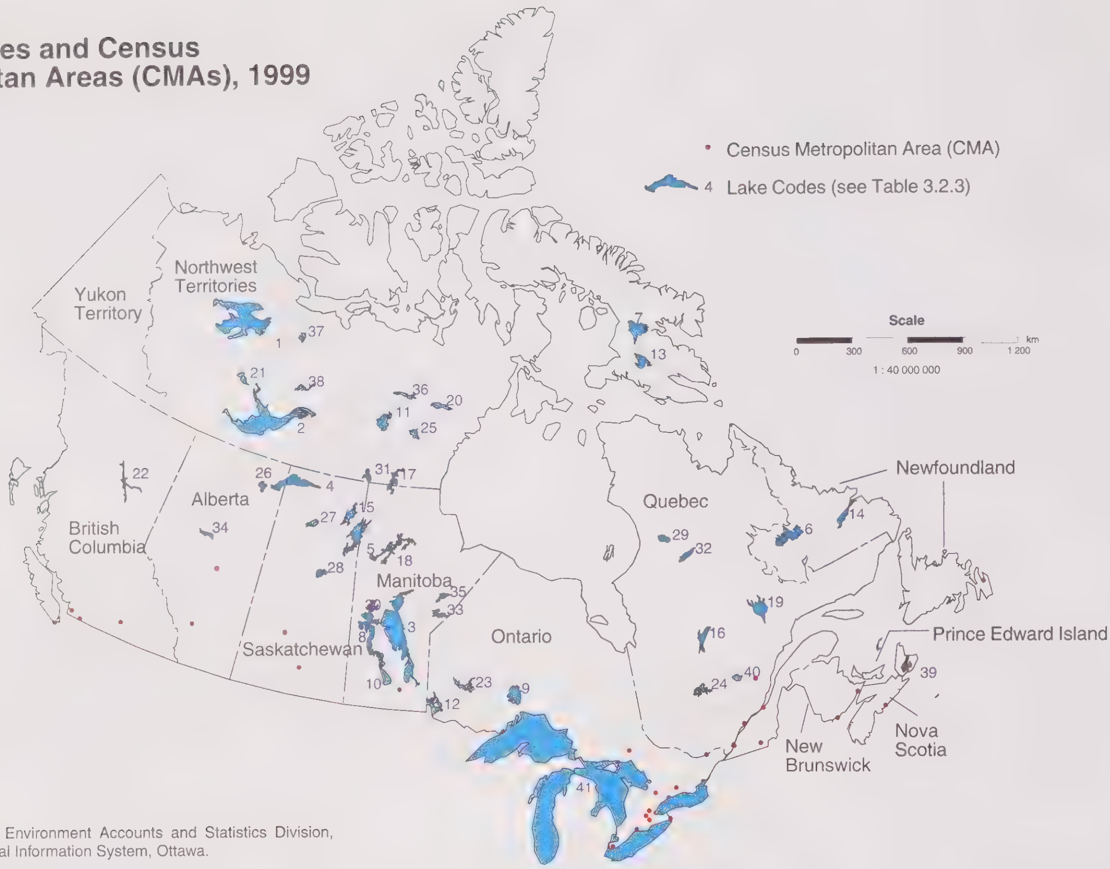


Source:
Geological Survey of Canada, 1999.

Map 3.2.4
Soils, 1996

Source:
Agriculture and Agri-Food Canada, Eastern Cereal and Oilseed Research Centre, 1996, *The Soil Orders of Canada,* Digital Soils Landscapes of Canada Data Base, Canadian Soil Information System (CanSIS), Ottawa.

Map 3.2.5
Major Lakes and Census Metropolitan Areas (CMAs), 1999



Source:
Statistics Canada, Environment Accounts and Statistics Division, 1999, Environmental Information System, Ottawa.

Table 3.2.3
Area, Elevation and Maximum Depth of Major Lakes[1]

Code[2]	Lake	Area	Elevation	Maximum depth	Code	Lake	Area	Elevation	Maximum depth
		km²	metres				km²	metres	
1	Great Bear Lake,[3] N.W.T.	31 328	156	413	24	Reservoir Gouin, Que.	1 570	404	..
2	Great Slave Lake, N.W.T.	28 568	156	614	25	Yathkyed Lake, N.W.T.	1 449	140	..
3	Lake Winnipeg, Man.	24 387	217	18	26	Lake Clair, Alta.	1 436	213	..
4	Lake Athabasca, Sask.	7 935	213	120	27	Cree Lake, Sask.	1 434	487	..
5	Reindeer Lake, Sask.	6 650	337	219	28	Lac la Ronge, Sask.	1 413	364	..
6	Smallwood Reservoir, Nfld.	6 527	471	..	29	Lac à l'Eau-Claire, Que.	1 383	404	..
7	Nettilling Lake, N.W.T.	5 542	30	..	30	Cedar Lake, Man.	1 353	253	..
8	Lake Winnipegosis, Man.	5 374	254	12	31	Kasba Lake, N.W.T.	1 341	336	..
9	Lake Nipigon, Ont.	4 848	260	165	32	Lac Bienville, Que.	1 249	426	..
10	Lake Manitoba, Man.	4 624	248	4	33	Island Lake, Man.	1 223	227	..
11	Dubawnt Lake, N.W.T.	3 833	236	..	34	Lesser Slave Lake, Alta.	1 168	577	..
12	Lake of the Woods, Ont.	3 150	323	21	35	Gods Lake, Man.	1 151	178	..
13	Amadjuak Lake, N.W.T.	3 115	113	..	36	Aberdeen Lake, N.W.T.	1 100	80	..
14	Melville Lake, Nfld.	3 069	tidal	..	37	Napaktulik Lake, N.W.T.	1 080	381	..
15	Wollaston Lake, Sask.	2 681	398	..	38	MacKay Lake, N.W.T.	1 061	431	..
16	Lac Mistassini, Que.	2 335	372	..	39	Bras d'Or Lake, N.S.	1 009	tidal	..
17	Nueltin Lake, N.W.T.	2 279	278	..	40	Lac Saint-Jean, Que.	1 003	98	..
18	Southern Indian Lake, Man.	2 247	254	..	41	Great Lakes[4]			..
19	Reservoir Manicouagan, Que.	1 942	360	..		Lake Huron, Ont.	36 000	177	229
20	Baker Lake, N.W.T.	1 887	2	..		Lake Superior, Ont.	28 700	184	405
21	Lac la Martre, N.W.T.	1 776	265	..		Lake Erie, Ont.	12 800	174	64
22	Williston Lake, B.C.	1 761	671	..		Lake Ontario, Ont.	10 000	75	244
23	Lac Seul, Ont.	1 657	357	.					

Notes:
1. Lakes with a total area of 1 000 km² or greater. See Map 3.2.5 for lake locations.
2. Refers to major lake labels on Map 3.2.5.
3. Largest lake wholly in Canada.
4. Area on Canadian side of boundary.

Source:
Natural Resources Canada and Forestry Canada, Canada Centre for Remote Sensing, GeoAccess.

Table 3.2.4
Estimated Wetland and Peatland Area by Province and Territory, 1986

Province/Territory	Wetlands[1]						Peatlands[2]
	Proportion of area in wetlands						
	0-5%	6-25%	26-50%	51-75%	76-100%	Total area	Total area
	km²						
Newfoundland	580	35 960	31 380	-	-	67 920	64 290
Prince Edward Island	40	-	-	-	-	40	80
Nova Scotia	220	1 550	-	-	-	1 770	1 580
New Brunswick	1 280	2 940	1 220	-	-	5 440	1 200
Quebec	6 280	45 790	35 060	28 490	5 890	121 510	117 130
Ontario	1 050	6 840	47 950	86 340	150 230	292 410	225 550
Manitoba	380	22 250	70 890	51 840	79 340	224 700	206 640
Saskatchewan	3 980	41 700	36 950	12 710	1 530	96 870	93 090
Alberta	1 070	10 800	32 490	68 730	23 950	137 040	126 730
British Columbia	3 520	6 620	1 460	16 560	3 040	31 200	12 890
Yukon Territory	1 980	1 850	7 640	3 630	-	277 940	251 110
Northwest Territories	22 410	75 200	95 480	65 210	19 640	15 100	12 980
Canada	**42 790**	**251 500**	**360 520**	**333 510**	**283 620**	**1 271 940**	**1 113 270**

Notes:
1. The extent and distribution of wetlands in Canada can only be estimated.
2. Based on both ecological and land use considerations, a thickness of 40 centimetres of peat is the minimum requirement for wetlands to be classified as peatlands.

Sources:
Energy, Mines and Resources Canada, 1986, "Distribution of Wetlands," *National Atlas of Canada*, 5th Edition, Ottawa. (Map.)
National Wetlands Working Group, Canada Committee on Ecological Land Classification, 1988, *Wetlands of Canada 1988*, Ecological Land Classification Series, No. 24, Environment Canada and Canadian Wildlife Service, Ottawa.

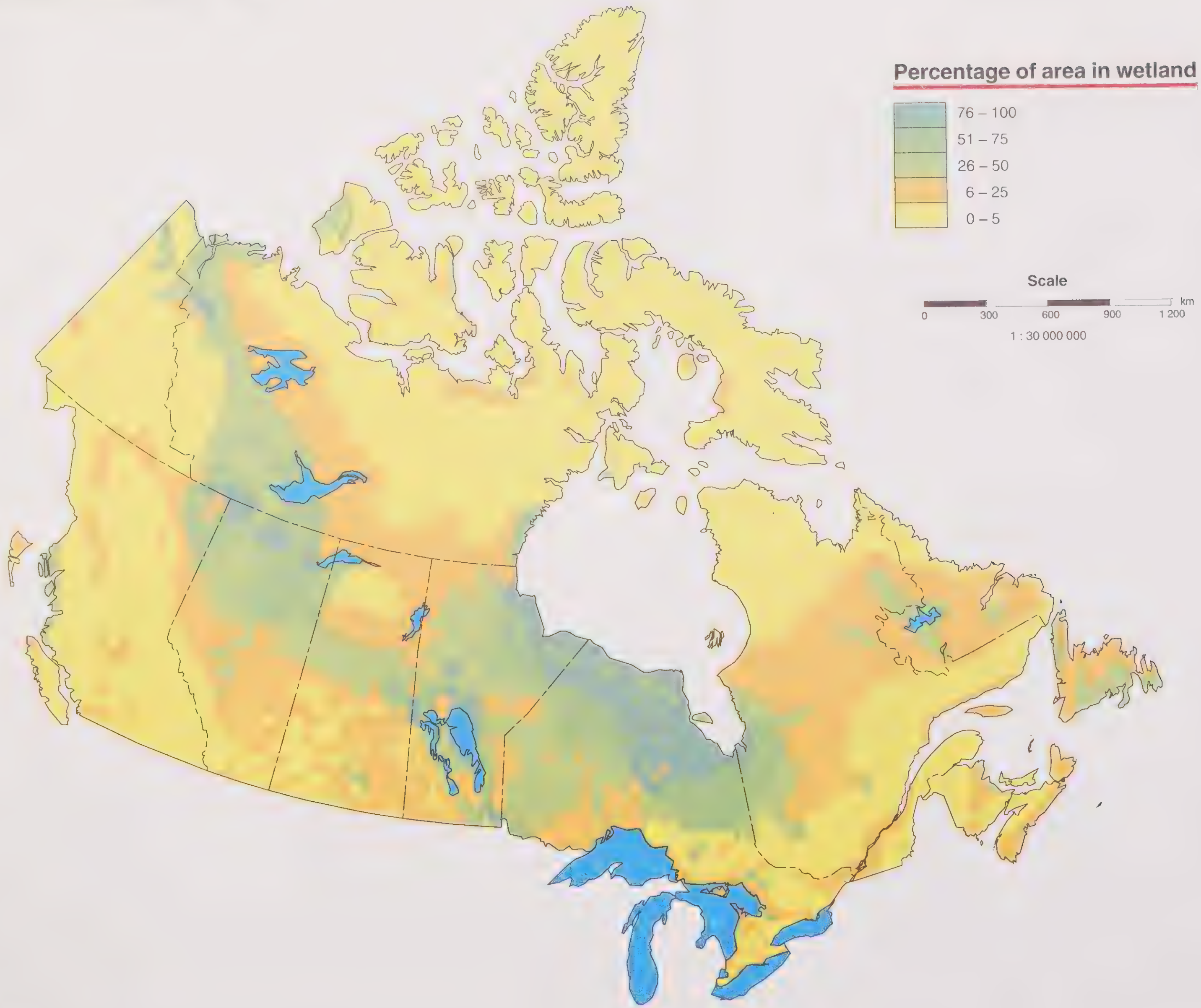
Wetlands and peatlands

Wetlands are lands that are saturated with water long enough to promote aquatic processes. Wetlands usually occur in poorly drained areas, which foster the growth of hydrophytic vegetation[1] and other biological activities such as the sustenance of large numbers of waterfowl, the storage and release of large quantities of water, and the production of large amounts of energy in the form of peat.[2, 3] Wetlands occupy a transitional position between water and land, since they are neither solid land nor open water. They include waterlogged soil, such as peat, where the production of plant materials exceeds decomposition. However, not all wetlands are peatlands. Peat accumulations must reach a minimum thickness of 40 centimetres to be classified as peatlands.[4] Wetlands are concentrated in the central provinces and are sparsest in the North and in mountainous areas (Table 3.2.4 and Map 3.2.6).

The conversion of wetland to other uses has been significant in many regions of Canada: central prairie wetland sloughs (70% converted); Atlantic salt marshes (65% converted); urban wetlands (80% to 98% converted); Pacific estuarine marshes (70% converted); and southern Ontario and St. Lawrence Valley hardwood and shoreline swamps (70% to 80% converted).

1. Plants, such as algae, that grow only in water or very wet soil.
2. Peat is a layer consisting largely of organic residues, originating under more or less water-saturated conditions through the incomplete decomposition of plant and animal constituents.
3. Tarnocai, C., 1980, "Canadian Wetland Registry," Proceedings of a Workshop on Canadian Wetlands, Environemnt Canada, Lands Directorate, Ecological Land Classification Series, No. 12, Ottawa.
4. National Wetlands Working Group, Canada Committee on Ecological Land Classification, 1988, *Wetlands of Canada 1988*, Ecological Land Classification Series, No. 24, Environment Canada and Canadian Wildlife Service, Ottawa.

Map 3.2.6
Distribution of Wetlands, 1986



Source:
Energy, Mines and Resources Canada, 1986, "Distribution of Wetlands," *National Atlas of Canada*, 5th Edition, Ottawa.

Organic soils

Organic soils contain a high level of organic matter.[1] The amount of organic matter in soils is affected by climate, vegetation, parent material,[2] landforms, land use and farming practices. Organic matter in soils varies widely—from 1% to 10% in most agricultural soils to more than 90% in wetlands, where peat has accumulated.

When previously undisturbed land is converted to agriculture, soil organic matter levels usually decline. This decline can be attributed to farming practices such as tillage and changes in moisture, aeration and temperature conditions. Harvesting also removes much of the plant material, leaving little to be worked back into the soil to replenish the organic matter.

Organic matter in the soil has many essential functions, which include storing and supplying plant nutrients, aiding the infiltration of water into the soil, retaining carbon, stabilizing the soil and reducing erosion, and controlling the effectiveness of pesticides. Soil organic matter typically contains about 50% carbon, 40% oxygen, 5% hydrogen, 4% nitrogen, and 1% sulphur.[3]

Organic soils cover approximately 14% of the land area of Canada.[4] Map 3.2.7 shows the distribution of organic soils in Canada; Table 3.2.5 shows the provincial and territorial distribution of organic soils.

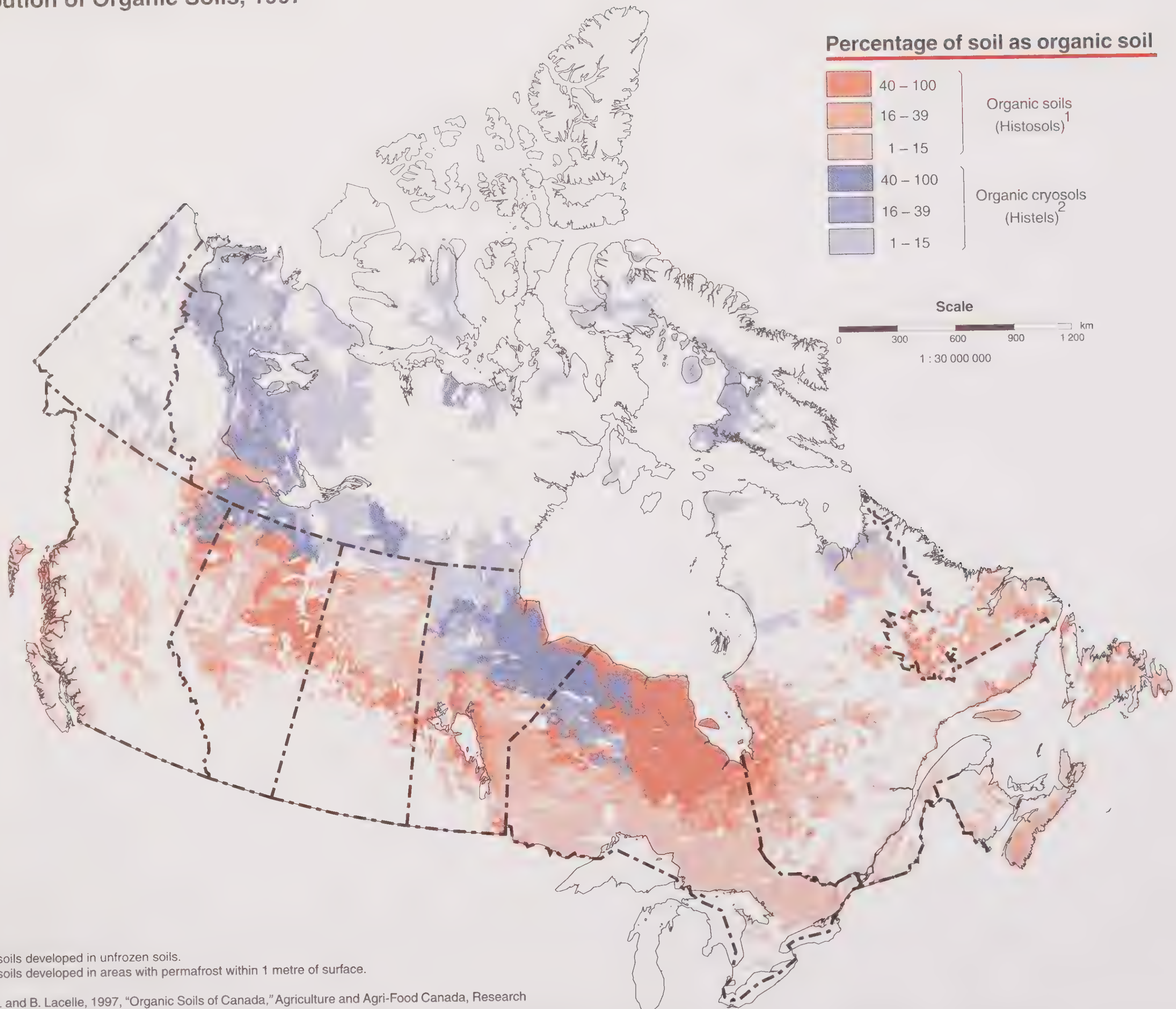
Table 3.2.5
Organic Soils by Province and Territory, 1997

Province/Territory	Organic soils: Unfrozen	Organic soils: Perennially frozen	Organic soils: Total
	km^2		
Newfoundland	58 534	-	58 534
Prince Edward Island	-	-	-
Nova Scotia	5 726	-	5 726
New Brunswick	3 444	-	3 444
Quebec	107 326	7 141	114 467
Ontario	280 305	67 135	347 440
Manitoba	82 064	108 082	190 146
Saskatchewan	62 993	1 034	64 027
Alberta	122 192	28 288	150 480
British Columbia	45 981	14 572	60 553
Yukon Territory	25 897	207 971	233 868
Northwest Territories	1 124	8 348	9 472
Canada	**795 586**	**442 571**	**1 238 157**

Source:
Tarnocai, C. and B. Lacelle, 1997, "Organic Soils of Canada," Agriculture and Agri-Food Canada, Research Branch, Ottawa. (Map.)

1. Decomposed plant and animal residues.
2. Materials from which soils are formed.
3. Gregorich, E.G. *et al.*, 1995, "Changes in soil organic matter," in D.F. Acton and L.J. Gregorich (eds.), *The Health of Our Soils: Toward sustainable agriculture in Canada,* Agriculture and Agri-Food Canada, Catalogue No. A53-1906/1995E, Centre for Land and Biological Resources Research, pp. 41–50, Ottawa.
4. Tarnocai, C., 1996, *The Amount of Organic Carbon in Various Soil Orders and Ecological Provinces in Canada*, Proceedings of the Carbon Sequestration in Soil Symposium, Columbus, Ohio.

Map 3.2.7
Distribution of Organic Soils, 1997



Notes:
1. Organic soils developed in unfrozen soils.
2. Organic soils developed in areas with permafrost within 1 metre of surface.

Source:
Tarnocai, C. and B. Lacelle, 1997, "Organic Soils of Canada," Agriculture and Agri-Food Canada, Research Branch, Ottawa. (Map.)

3.3 Climate

Climate can be defined as the average weather that occurs in a specific area over a period of time. It is the normal weather pattern that recurs at a given place, with small variations, from year to year. Humans rely heavily on the regularity of climate patterns for almost all of their activities. Local regional climates are influenced by latitude, altitude, physiography and the proximity of large bodies of water.

Climate is measured using various weather elements as indicators. The two essential indicators are temperature and precipitation, but other data—including sunshine, wind, atmospheric pressure, humidity and evaporation—can also be collected to ascertain climatic conditions at a given location. These elements are measured systematically at a site over time, accumulating an archive of observations from which climatic summaries can be derived for that location. The standard practice is to base climate calculations on the last three complete decades. These 'climate normals' are updated at the beginning of every new decade.

Regular climate observations in Canada began in Toronto on December 25, 1839, and data are now collected from 1 724 daily and principal climatological stations.[1] Daily stations provide readings once or twice daily for temperature and precipitation while principal stations provide hourly readings of more detailed weather information for forecasting purposes. A selection of these weather stations is displayed on Map 3.3.1.

Temperature

Drastic changes in temperature signal the change from one season to the next in Canada. Although winters can be bitterly cold, summers can be hot and dry, or hot and humid, depending on the region. The country's interior, for example, has a wide range of temperatures, characteristic of a continental climate. Summers are warmer and drier—but also relatively shorter—on the Prairies than in the coastal regions. The Rocky Mountain range diverts cold arctic air from the West Coast and funnels it toward the Prairies, making for long, cold winters.

The Pacific Coast enjoys the shortest and mildest winters because of the moderating effect of warm air from the Pacific Ocean. Along the Atlantic the moderating effect of ocean air is less pronounced, but occasional influxes of warm Atlantic air maintain average winter temperatures along that coast at -2.5°C.

1. Gary Beaney, Environment Canada, Atmospheric Monitoring and Water Survey Directorate, personal communication.

Map 3.3.1
Selected Weather Stations

Source:
Environment Canada, Atmospheric Environment Service, 1993, *Canadian Climate Normals, 1961-1990*, Vols. 1-6, Ottawa.

In the mountain regions of Canada, altitude is the most influential factor in determining the climate. Mountain slopes typically receive wet, heavy snow, while valleys in the rainshadow enjoy dry, hot summers. Those areas in Canada that lie away from the coast and the mountains experience temperatures that vary relatively directly with latitude.

Although Canada is often perceived as a cold country, for the most part it enjoys a temperate climate. Figure 3.3.1 shows the number of days in Canada where the maximum temperature is above freezing (0°C). While Canadian winters are undoubtedly cold, summers are comparably hot. Mid-July afternoon temperatures may exceed 25°C over much of the country's interior. Coastal areas remain five to eight degrees cooler because of the effect of sea breezes, and local cooling can be felt on the shores of large inland lakes and bays. Maps 3.3.2 and 3.3.3 display the mean annual daily maximum and minimum temperatures recorded across Canada for the period 1961 to 1990.

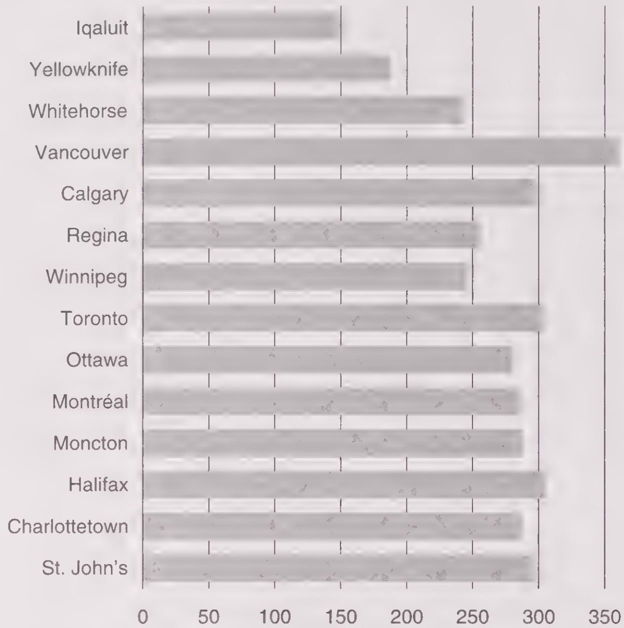
Precipitation

Canada receives approximately 5.5 trillion tonnes of rain, snow and hail every year. This precipitation is unevenly distributed across the country, both spatially and temporally. The Pacific Coast receives the most, and the greatest amount of its rain and snow falls in winter. Less than 100 kilometres east lies one of the driest areas of the country, owing to its location in the rainshadow of the Coast Mountains. This rainshadow continues across the Prairies, where most of the precipitation falls in June. East of the Prairies, precipitation increases at the rate of approximately 40 millimetres every 100 kilometres, from 500 millimetres per year at Winnipeg to 1 500 millimetres per year at Halifax. The Arctic receives very little rainfall and even less snowfall, making it the driest region in the country. Figure 3.3.2 shows the average annual precipitation recorded at airport weather stations for major cities across Canada. Map 3.3.4 displays the mean annual precipitation across Canada for the period 1961 to 1990.

Canada's average precipitation is 535 millimetres per year, compared with 690 millimetres per year worldwide. Snowfall accounts for 36% of Canada's precipitation, while the rest of the world sees only 5% of its precipitation fall as snow.

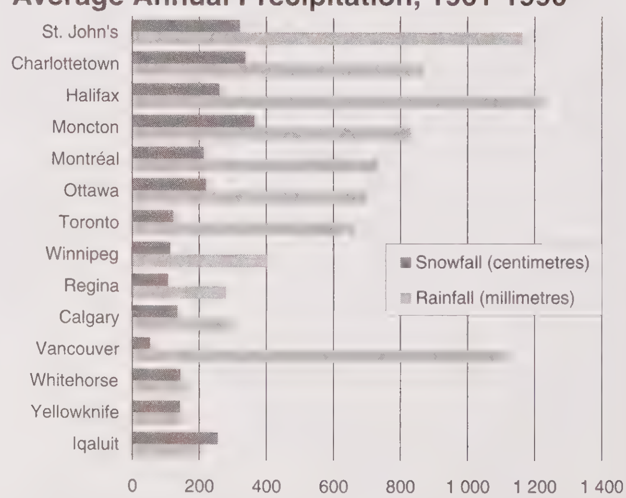
Tables 3.3.1, 3.3.2 and 3.3.3 summarize temperature, precipitation and other climate data for selected weather stations across Canada for the period 1961 to 1990.

Figure 3.3.1
Average Annual Number of Days with Above-Freezing Temperatures, 1961-1990



Source:
Environment Canada, Atmospheric Environment Service, 1993, *Canadian Climate Normals, 1961-1990,* Vols. 1-6, Ottawa.

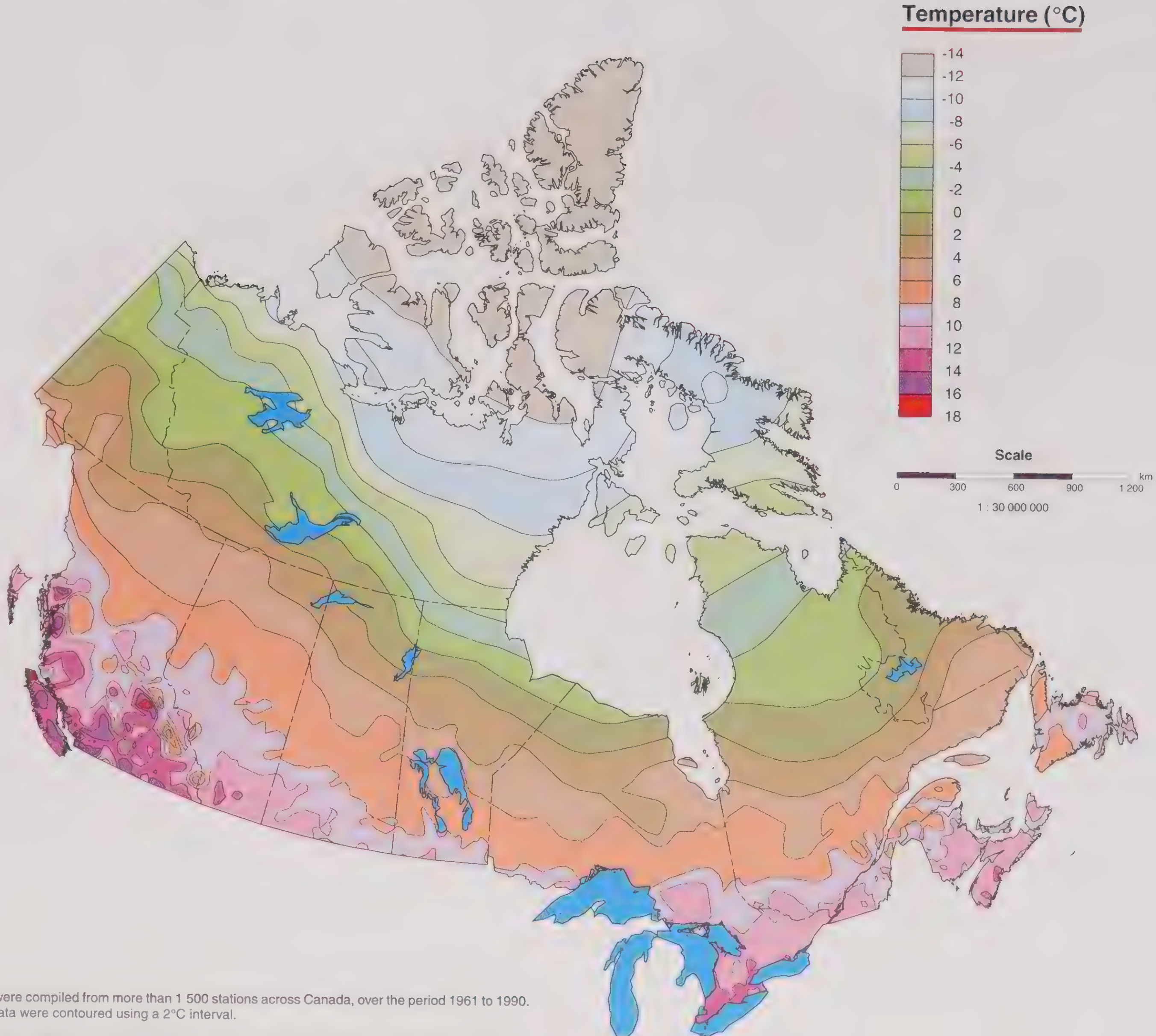
Figure 3.3.2
Average Annual Precipitation, 1961-1990



Source:
Environment Canada, Atmospheric Environment Service, 1993, *Canadian Climate Normals, 1961-1990,* Vols. 1-6, Ottawa.

Map 3.3.2

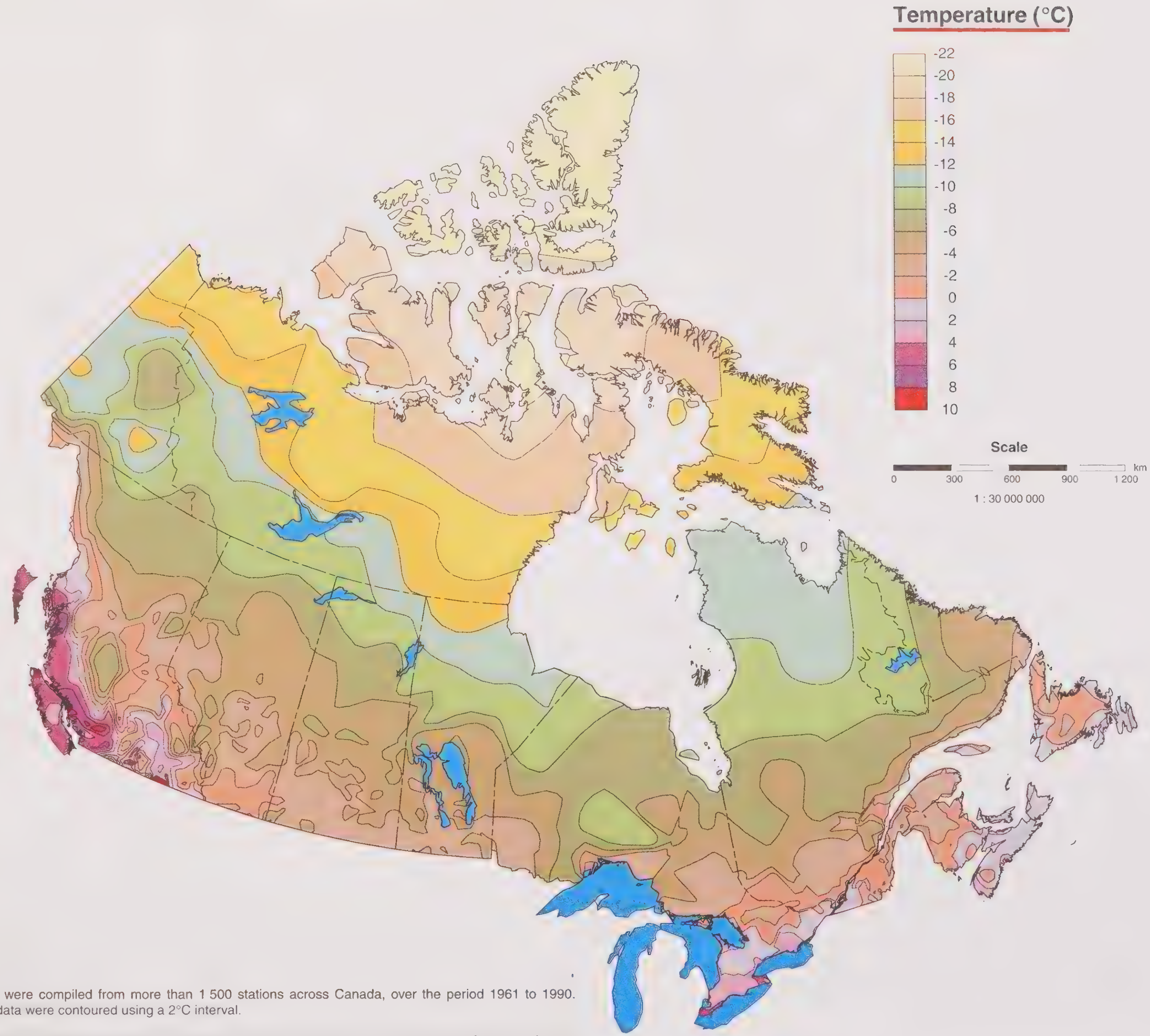
Mean Annual Daily Maximum Temperature, 1961-1990



Note:
Temperature data were compiled from more than 1 500 stations across Canada, over the period 1961 to 1990. Individual station data were contoured using a 2°C interval.

Source:
Environment Canada, Atmospheric, Climate and Water Systems Branch, 1993, *The 1961-1990 Canadian Climate Normals Atlas*, Ottawa

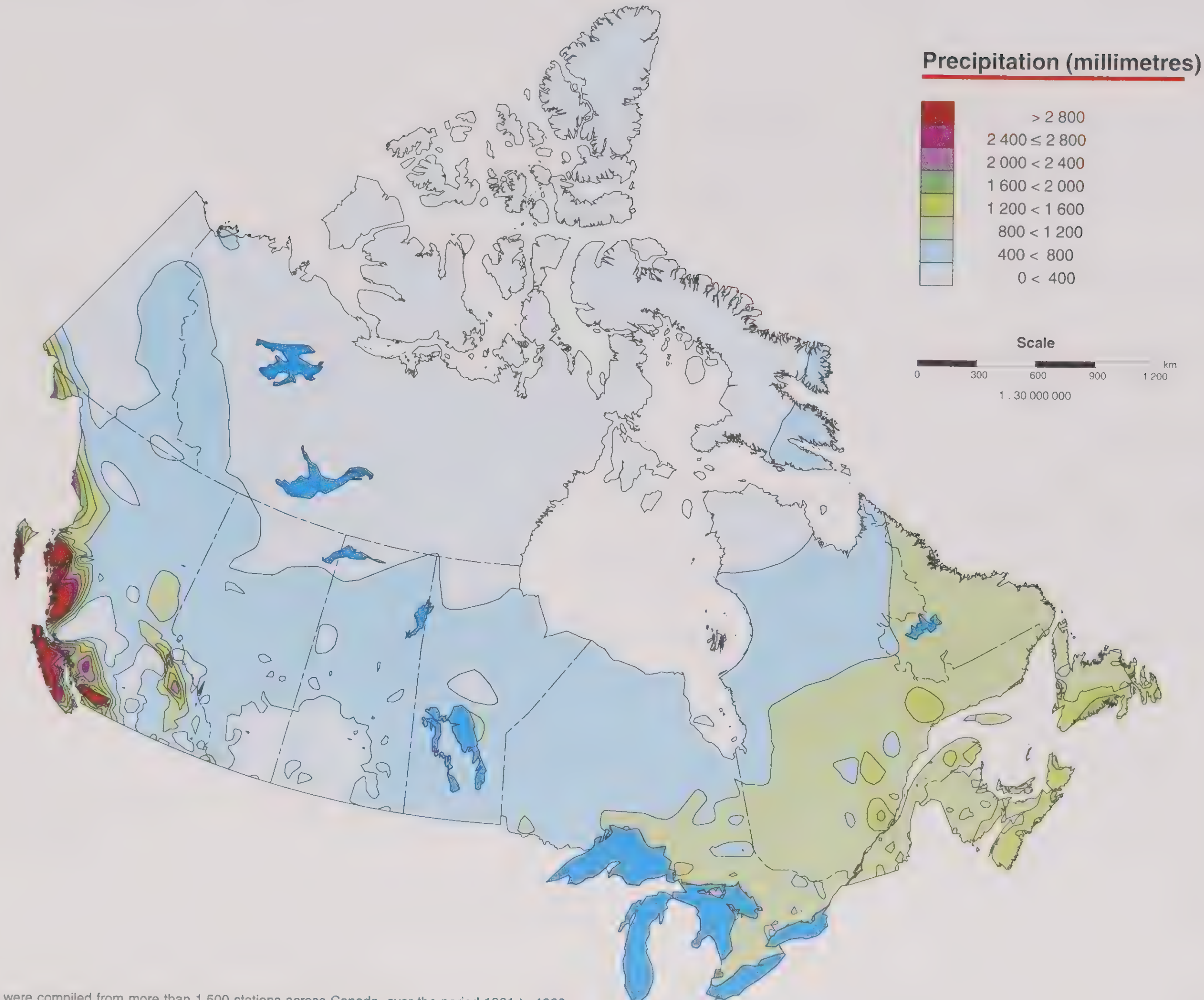
Map 3.3.3
Mean Annual Daily Minimum Temperature, 1961-1990



Note:
Temperature data were compiled from more than 1 500 stations across Canada, over the period 1961 to 1990. Individual station data were contoured using a 2°C interval.
Source:
Environment Canada, Atmospheric, Climate and Water Systems Branch, 1993, *The 1961-1990 Canadian Climate Normals Atlas*, Ottawa.

Map 3.3.4

Mean Annual Precipitation, 1961-1990



Note:
Temperature data were compiled from more than 1 500 stations across Canada, over the period 1961 to 1990. Individual station data were contoured using a 200-millimetre interval. However, data on this map are displayed at a 400 millimetre contour interval.

Source:
Environment Canada, Atmospheric Climate and Water Systems Branch, 1993, *The 1961-1990 Canadian Climate Normals Atlas*, Ottawa.

Table 3.3.1
Average Daily Temperatures by Month for Selected Weather Stations, 1961-1990

Station[2]	January	February	March	April	May	June	July	August	September	October	November	December	Annual
	Average[1] daily temperature °C												
Goose Bay, Nfld.	-17.3	-15.5	-9.2	-1.8	5.1	10.9	15.5	14.2	9.0	2.5	-4.0	-13.4	-0.3
Gander, Nfld.	-6.8	-7.4	-3.8	1.1	6.5	11.6	16.3	15.5	11.1	5.9	1.4	-3.9	4.0
St. John's, Nfld.	-4.3	-5.0	-2.5	1.3	5.8	10.9	15.4	15.3	11.6	7.0	3.1	-1.7	4.7
Charlottetown, P.E.I.	-7.7	-8.0	-3.4	2.3	8.8	14.4	18.4	18.0	13.4	8.0	2.5	-4.1	5.2
Sydney, N.S.	-5.4	-6.5	-2.9	1.9	7.5	13.1	17.6	17.6	13.2	8.3	3.6	-2.0	5.5
Halifax, N.S.	-5.8	-6.0	-1.7	3.6	9.4	14.7	18.3	18.1	13.8	8.5	3.2	-3.1	6.1
Yarmouth, N.S.	-3.0	-3.3	0.2	4.7	9.3	13.4	16.3	16.5	13.6	9.3	4.8	-0.4	6.8
Moncton, N.B.	-8.7	-8.1	-3.0	2.9	9.6	15.0	18.5	17.7	12.8	7.4	1.6	-5.7	5.0
Saint John, N.B.	-8.2	-7.7	-2.6	3.2	9.1	13.8	16.9	16.7	12.7	7.5	2.1	-5.0	4.9
Nitchequon, Que.	-23.5	-21.8	-15.1	-6.2	1.8	9.7	13.6	12.0	6.5	0.0	-8.0	-19.3	-4.2
Chapais 2, Que.	-18.4	-16.8	-9.4	-0.5	7.4	13.6	16.1	14.5	9.2	3.0	-5.0	-15.3	-0.1
Kuujjuaq, Que.	-23.5	-23.1	-18.5	-9.4	-0.1	6.8	11.0	10.4	5.3	-0.8	-8.3	-18.1	-5.8
Kuujjuarapik, Que.	-22.8	-23.1	-17.5	-7.1	1.2	6.3	10.2	10.6	7.2	2.1	-5.0	-16.6	-4.5
Québec, Que.	-12.4	-11.0	-4.6	3.3	10.8	16.3	19.1	17.6	12.5	6.5	-0.5	-9.1	4.0
Sept-Îles, Que.	-14.6	-13.0	-6.8	0.0	5.9	11.6	15.2	14.2	9.2	3.4	-2.7	-11.0	0.9
Montréal, Que.	-10.3	-8.8	-2.4	5.7	12.9	18.0	20.8	19.4	14.5	8.3	1.6	-6.9	6.1
Ottawa, Ont.	-10.8	-9.2	-2.7	5.6	12.8	17.9	20.8	19.2	14.3	7.9	1.0	-7.6	5.8
Kapuskasing, Ont.	-18.5	-16.2	-9.0	0.5	8.6	13.8	17.0	15.3	10.0	4.2	-4.6	-14.9	0.5
Thunder Bay, Ont.	-15.0	-12.8	-5.6	2.7	9.0	13.9	17.7	16.4	11.2	5.4	-2.6	-11.3	2.4
Toronto, Ont.	-6.7	-6.1	-0.8	6.0	12.3	17.4	20.5	19.5	15.2	8.9	3.2	-3.5	7.2
Windsor, Ont.	-5.0	-3.9	1.7	8.1	14.4	19.7	22.4	21.3	17.4	10.9	4.7	-1.9	9.1
The Pas, Man.	-21.4	-17.5	-10.0	0.5	8.7	14.8	17.7	16.4	9.9	3.5	-7.7	-18.0	-0.3
Winnipeg, Man.	-18.3	-15.1	-7.0	3.8	11.6	16.9	19.8	18.3	12.4	5.7	-4.7	-14.6	2.4
Churchill, Man.	-26.9	-25.4	-20.2	-10.0	-1.1	6.1	11.8	11.3	5.5	-1.4	-12.5	-22.7	-7.1
Regina, Sask.	-16.5	-12.9	-6.0	4.1	11.4	16.4	19.1	18.1	11.6	5.1	-5.1	-13.6	2.6
Saskatoon, Sask.	-17.5	-13.9	-7.0	3.9	11.5	16.2	18.6	17.4	11.2	4.8	-6.0	-14.7	2.0
Calgary, Alta.	-9.6	-6.3	-2.5	4.1	9.7	14.0	16.4	15.7	10.6	5.7	-3.0	-8.3	3.9
Edmonton, Alta.	-14.2	-10.8	-5.4	3.7	10.3	14.2	16.0	15.0	9.9	4.6	-5.7	-12.2	2.1
Victoria, B.C.	3.4	4.8	6.1	8.4	11.4	14.3	16.2	16.2	13.8	9.7	6.0	3.8	9.5
Penticton, B.C.	-2.0	0.7	4.5	8.7	13.3	17.6	20.3	19.9	14.7	8.7	3.2	-1.1	9.0
Vancouver, B.C.	3.0	4.7	6.3	8.8	12.1	15.2	17.2	17.4	14.3	10.0	6.0	3.5	9.9
Prince Rupert, B.C.	0.8	2.5	3.7	5.5	8.4	10.9	12.9	13.3	11.3	8.0	3.8	1.3	6.9
Prince George, B.C.	-9.9	-5.4	-0.7	4.7	9.4	13.1	15.3	14.6	9.8	4.8	-3.1	-8.4	3.7
Mayo, Y.T	-26.9	-19.4	-10.4	0.0	7.9	13.6	15.6	12.8	6.5	-2.2	-16.8	-23.5	-3.6
Whitehorse, Y.T	-18.7	-13.1	-7.2	0.3	6.6	11.6	14.0	12.3	7.3	0.7	-10.0	-15.9	-1.0
Resolute, N.W.T.	-32.0	-33.0	-31.2	-23.5	-11.0	-0.6	4.0	1.9	-5.0	-15.2	-24.3	-29.0	-16.6
Alert, N.W.T.	-31.9	-33.6	-33.1	-25.1	-11.6	-1.0	3.4	1.0	-9.7	-19.5	-27.0	-29.5	-18.5
Clyde, N.W.T.	-26.9	-28.0	-26.6	-19.0	-8.1	0.5	4.2	3.9	-0.3	-7.3	-17.2	-24.0	-12.4
Iqaluit, N.W.T.	-25.8	-26.8	-23.5	-14.7	-4.2	3.4	7.7	6.8	2.3	-4.9	-12.7	-22.1	-9.5
Baker Lake, N.W.T.	-32.6	-32.1	-28.0	-17.8	-6.7	4.1	11.1	9.4	2.4	-7.4	-20.6	-28.3	-12.2
Inuvik, N.W.T.	-28.8	-28.5	-24.1	-14.1	-0.7	10.6	13.8	10.5	3.3	-8.2	-21.5	-26.1	-9.5
Yellowknife, N.W.T.	-27.9	-24.5	-18.5	-6.2	5.0	13.1	16.5	14.1	6.7	-1.4	-14.8	-24.1	-5.2

Notes:
1. Averaged over the period 1961 to 1990.
2. All weather stations in this table are located at airports.

Source:
Environment Canada, Atmospheric Environment Service, 1993, *Canadian Climate Normals, 1961-1990*, Vols. 1-6, Ottawa.

Table 3.3.2
Annual Averages of Various Weather Conditions for Selected Weather Stations, 1961-1990

Station[3]	Average[1] number of days with:[2] Temperatures above 0.0°C	Rain[4]	Snow[5]	Freezing precipitation[6]	Fog[7]	Thunder[8]	Average number of hours of bright sunshine
	days						hours
Goose Bay, Nfld.	236	109	99	14	11	8	1 607.6
Gander, Nfld.	281	147	101	37	75	5	
St. John's, Nfld.	297	161	87	38	121	4	..
Charlottetown, P.E.I.	287	125	71	17	47	9	..
Sydney, N.S.	300	139	73	19	78	9	1 804.6
Halifax, N.S.	305	128	63	16	122	10	..
Yarmouth, N.S.	324	124	51	8	120	12	1 821.8
Moncton, N.B.	288	124	65	17	59	12	1 939.0
Saint John, N.B.	298	124	59	12	102	11	1 893.7
Nitchequon, Que.	201	96	122	8	16	10	
Chapais 2, Que.	229	101	76	..	..	..	
Kuujjuaq, Que.	184	75	112	9	18	3	..
Kuujjuarapik, Que.	200	83	108	10	47	5	..
Québec, Que.	265	117	76	15	31	22	1 910.4
Sept-Îles, Que.	248	101	76	9	53	7	
Montréal, Que.	286	117	61	13	18	26	..
Ottawa, Ont.	280	110	64	17	36	24	..
Kapuskasing, Ont.	236	103	81	..	..	..	1 728.1
Thunder Bay, Ont.	263	89	61	7	35	25	2 183.3
Toronto, Ont.	304	107	47	10	34	28	..
Windsor, Ont.	315	111	44	10	35	35	..
The Pas, Man.	228	68	70	12	15	23	2 203.2
Winnipeg, Man.	246	73	56	13	17	28	2 377.3
Churchill, Man.	169	64	96	21	47	7	1 820.7
Regina, Sask.	256	62	56	14	28	23	2 364.6
Saskatoon, Sask.	250	60	57	10	22	19	..
Calgary, Alta.	298	62	58	6	22	25	2 394.6
Edmonton, Alta.	269	72	57	8	18	25	2 303.2
Victoria, B.C.	362	148	11	--	24	3	2 081.9
Penticton, B.C.	335	84	28	1	2	14	..
Vancouver, B.C.	361	159	13	1	34	6	1 919.3
Prince Rupert, B.C.	354	223	29	..	34	3	1 211.8
Prince George, B.C.	294	107	75	6	57	22	1 942.4
Mayo, Y.T.	220	65	67	..	..	..	..
Whitehorse, Y.T.	243	58	74	2	15	6	1 852.4
Resolute, N.W.T.	87	21	84	15	68	-	
Alert, N.W.T.	77	10	98	..	..	.	
Clyde, N.W.T.	119	20	97	..	..	..	..
Iqaluit, N.W.T.	149	47	114	5	15	--	1 508.3
Baker Lake, N.W.T.	136	39	77	10	42	2	
Inuvik, N.W.T.	154	40	98	9	24	2	
Yellowknife, N.W.T.	188	50	80	11	19	6	..

Notes:
1. Averaged over the period 1961 to 1990.
2. A 'day with' refers to one or more individual occurrences of a weather phenomenon in a single day.
3. All weather stations in this table are located at airports.
4. Rain is a measurable amount of liquid precipitation (rain, showers or drizzle) equal to or greater than 0.2 millimetres.
5. Snow is a measurable amount of solid precipitation (snow, snow grains, ice crystals, or ice and snow pellets) equal to or greater than 0.2 centimetres.
6. Freezing precipitation is any quantity of rain or drizzle that freezes on impact.
7. Fog, a suspension of small water droplets in air, reduces the horizontal visibility at eye level to less than 1 kilometre.
8. Thunder is reported when thunder is heard or lightning or hail is seen.

Source:
Environment Canada, Atmospheric Environment Service, 1993, *Canadian Climate Normals, 1961-1990*, Vols. 1-6, Ottawa.

Table 3.3.3

Average Annual Degree-days, Wind and Precipitation for Selected Weather Stations, 1961-1990

	Average[1] degree-days[2]			Wind	Precipitation		
Station[3]	Heating (<18°C)	Cooling (>18°C)	Growing (>5°C)	Average speed[4]	Average rainfall	Average snowfall	Total[5]
	degree-days			kilometres/hour	millimetres	centimetres	millimetres
Goose Bay, Nfld.	6 726	41	995	16	557.3	463.8	959.5
Gander, Nfld.	5 164	47	1 238	21	737.9	443.8	1 181.6
St. John's, Nfld.	4 865	32	1 209	24	1 163.1	322.1	1 481.7
Charlottetown, P.E.I.	4 748	94	1 636	19	868.6	338.7	1 200.8
Sydney, N.S.	4 636	84	1 527	20	1 156.2	329.5	1 480.1
Halifax, N.S.	4 421	91	1 707	18	1 222.7	261.4	1 473.5
Yarmouth, N.S.	4 106	17	1 579	18	1 077.1	205.3	1 259.4
Moncton, N.B.	4 833	97	1 649	17	834.5	365.5	1 228.5
Saint John, N.B.	4 865	32	1 209	24	1 163.1	322.1	1 481.7
Nitchequon, Que.	8 105	9	730	16	517.6	328.2	827.2
Chapais 2, Que.	6 661	53	1 196	..	647.7	271.8	919.9
Kuujjuaq, Que.	8 675	4	492	16	262.0	270.5	523.5
Kuujjuarapik, Que.	8 230	13	556	17	387.1	238.2	614.9
Québec, Que.	5 208	123	1 688	15	881.3	337.0	1 207.7
Sept-Îles, Que.	6 229	10	1 005	16	728.5	415.1	1 127.9
Montréal, Que.	4 575	237	2 079	15	736.3	214.2	939.7
Ottawa, Ont.	4 688	232	2 045	14	701.8	221.5	910.5
Kapuskasing, Ont.	6 454	81	1 336	13	557.7	325.7	861.0
Thunder Bay, Ont.	5 749	69	1 427	13	546.8	195.5	703.5
Toronto, Ont.	4 174	231	2 090	15	664.7	124.2	780.8
Windsor, Ont.	3 615	396	2 544	16	787.8	123.3	901.6
The Pas, Man.	6 736	82	1 395	15	323.3	170.2	451.9
Winnipeg, Man.	5 874	189	1 802	18	404.4	114.8	504.4
Churchill, Man.	9 177	14	562	21	235.4	200.1	411.6
Regina, Sask.	5 756	155	1 723	20	280.5	107.4	364.0
Saskatoon, Sask.	5 944	127	1 658	17	253.8	105.4	347.2
Calgary, Alta.	5 195	44	1 435	16	300.3	135.4	398.8
Edmonton, Alta.	5 827	33	1 352	13	357.8	127.1	465.8
Victoria, B.C.	3 109	22	1 864	10	812.8	46.9	857.9
Penticton, B.C.	3 469	205	2 163	12	250.0	73.0	308.5
Vancouver, B.C.	3 002	38	2 018	12	1 117.2	54.9	1 167.4
Prince Rupert, B.C.	4 050	-	1 181	14	2 409.1	142.6	2 551.6
Prince George, B.C.	5 241	19	1 238	10	415.2	233.8	614.7
Mayo, Y.T.	7 891	17	1 016	6	201.4	145.0	318.4
Whitehorse, Y.T.	6 947	6	871	14	159.6	145.2	268.8
Resolute, N.W.T.	12 630	-	29	21	50.4	97.3	139.6
Alert, N.W.T.	13 195	-	30	9	14.4	164.9	154.2
Clyde, N.W.T.	11 097	-	45	13	47.2	197.3	225.6
Iqaluit, N.W.T.	10 050	-	177	16	192.9	256.8	424.1
Baker Lake, N.W.T.	11 011	1	389	21	143.5	130.1	261.8
Inuvik, N.W.T.	10 040	18	682	10	116.0	175.2	257.4
Yellowknife, N.W.T.	8 477	32	1 039	15	154.0	143.9	267.3

Notes:

1. Averaged over the period 1961 to 1990.
2. A degree-day is used as an index. Each degree of mean temperature above or below a given temperature is counted as one degree-day. Heating and cooling degree-days are used to establish the heating and cooling requirements of buildings: each degree of mean temperature below or above 18°C is counted as one heating degree-day or cooling degree-day, respectively. Growing degree-days are used in agriculture as an index of crop growth: each degree of mean temperature above 5°C is counted as one growing degree-day.
3. All weather stations in this table are located at airports.
4. Average speed is the average of all winds and calms.
5. Total precipitation is the total water equivalent of snowfall and rainfall (where 1 centimetre of snowfall = 1 millimetre of rain).

Source:

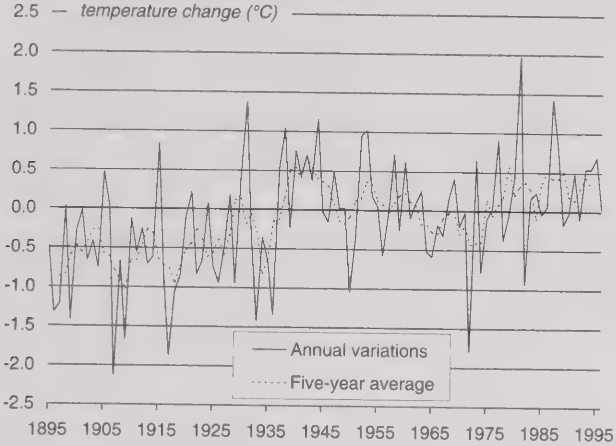
Environment Canada, Atmospheric Environment Service, 1993, *Canadian Climate Normals, 1961-1990*, Vols. 1-6, Ottawa.

Climate trends

According to Environment Canada, Canada's top news stories in 1996, 1997 and 1998 were weather events. In 1996, Canada saw its first billion-dollar disaster with Quebec's Saguenay River flood. This was followed by Manitoba's Red River flood in 1997, the worst flooding the area had experienced in 150 years. In 1998, the 'Ice Storm of the Century' that struck eastern Canadians in early January was reportedly the most destructive and disruptive storm in Canadian history.[1] Table 3.3.4 outlines the top 10 weather stories of 1998, ranked by Environment Canada according to the impact they had on Canadians.

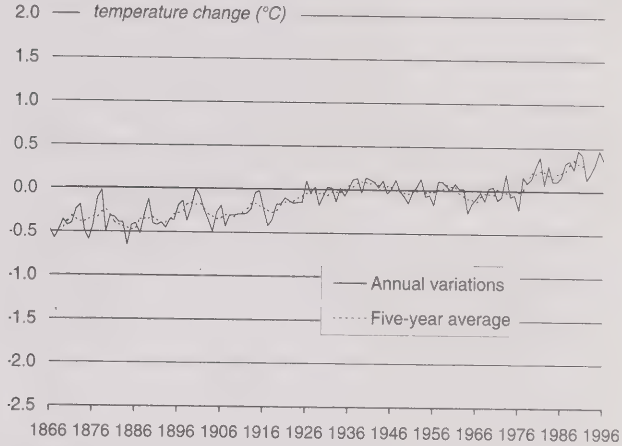
Not unlike the rest of the world, Canada has experienced a warming trend over the last century. The average annual temperature in Canada has risen by 1.0°C between 1895 and 1995, comparable to the global average of approximately 0.5°C. Figures 3.3.3 and 3.3.4 show the trends in average air temperatures over the last 100 years.

Figure 3.3.3
Trends in Canadian Average Air Temperatures, 1895-1996



Sources:
Environment Canada, Atmospheric Environment Service.
P.D. Jones and T.M.L. Wigley, University of East Anglia, Norwich, U.K., personal communication.

Figure 3.3.4
Trends in Global Average Air Temperatures, 1866-1996



Sources:
Environment Canada, Atmospheric Environment Service.
P.D. Jones and T.M.L. Wigley, University of East Anglia, Norwich, U.K., personal communication.

1. Statistics Canada, 1998, *The St. Lawrence River Valley 1998 Ice Storm: Maps and Facts*, Catalogue No. 16F0021XIB, Ottawa.

Table 3.3.4
Top 10 Canadian Weather Stories of 1998

Rank	Event	Location	Date
1	'Ice Storm of the Century'	Eastern Canada	January 4-10,1998
2	'A Year-Long Heat Wave'	Canada	December 1997 to November 1998
3	'Costliest Forest Fire Season on Record'	Alberta, Saskatchewan, British Columbia, Northwestern Ontario, and the southern half of the Northwest and Yukon territories	May to September 1998
4	'The Warmest, Longest Summer in Memory'	Canada	June, July and August 1998
5	'Near-Record Dry Year'	Canada	December 1997 to November 1998
6	'Early Planting and Record Early Harvest'	Canada	April 1998; mid-August to late September 1998
7	'Winter and Spring Flooding in Eastern Canada'	Eastern Canada	late January and late March 1998
8	'A Lingering Fall and Most Reluctant Winter'	Canada	September, October and November 1998
9	'Three Memorable Snowstorms'	Southern Manitoba and Saskatchewan	February 25, 1998
		Calgary	March 17, 1998
		Saskatchewan	October 11, 1998
10	'Hurricane Season' and	Atlantic Ocean	September 1998
	'British Columbia's Big Blows'	British Columbia	late November to early December 1998

Source:
Environment Canada, Atmospheric Environment Service, Communications Directorate, 1998, *Top Ten Weather Stories of 1998*, Press release, December 21, Ottawa.

Text Box 3.3.1

Record Warmth

In 1998, Canada witnessed its warmest year on record since measurements began nationwide in 1948. Statistically, a year like 1998 should occur once every 2 500 years. The temperature that year, 2.4°C above normal, combined with global above-normal temperatures to add more evidence to the argument that we are living in a warmer climate. As of December 1998, 6 of the 11 months recorded that year had set new warmest temperature records in Canada (February, April, May, July, August and September) and 2 months (June and November) were the second warmest since 1948. Table 3.3.5 indicates the temperature departures from normal by climate region for 1998.

The warming trend in Canada was reflected worldwide, where every month from May 1997 to October 1998 was the warmest on record since 1860. Although one year of warm weather alone is not evidence of global warming, the following facts support the compelling argument that our climate is indeed changing:

- 1998 was the 20th consecutive year with above-normal temperatures worldwide;
- in the past 140 years, 7 of the 10 warmest years have occurred since 1990;
- the 1990s have been the warmest decade of the century; and
- the 20th century was the hottest century for the last 1 200 years.

Source:
Environment Canada, Atmospheric Environment Service, Communications Directorate, 1998, *Top Ten Weather Stories of 1998*, Press release, December 21, Ottawa.

Text Box 3.3.2

El Niño

During the winter of 1997-98, Canada experienced the effects of what scientists tracked as the strongest El Niño in a century and a half. As a result, southern regions in Canada experienced a warmer winter with less precipitation than usual, while the extreme northeast region of Canada witnessed below-normal winter temperatures. The effects of El Niño across Canada in 1998 include the following:

- Winnipeg recorded its second-warmest December in 120 years;
- most grain-growing and central regions received one-half to one-quarter of the normal amount of precipitation during November and December;
- a record warm February helped to produce the warmest winter in 66 years in southern Ontario;
- the ice wine industry reported losses in the range of $10–15 million;
- Canada's worst-ever ice storm hit central and eastern portions of the country during the first week of January. It brought six continuous days of freezing rain—a total of more than 100 millimetres in some areas.

However, natural forces such as El Niño cannot fully explain the 12 months of record-setting warm weather experienced from December 1997 to November 1998 in Canada.

Source:
Environment Canada, Atmospheric Environment Service, *Fact Sheet—El Niño 1997-98*, <http://www1.tor.ec.gc.ca/elnino>, (accessed December 8, 1999).

Table 3.3.5

Annual Regional Temperature Departures: Trends and Extremes, 1948-1998

		Extreme years					
		Coldest		Warmest		Annual 1998[1]	
Climate region[2]	Trend[3]	Year on record	Departure[4]	Year on record	Departure[4]	Rank[5]	Departure[4]
	°C	year	°C	year	°C		°C
Atlantic Canada	-0.5	1972	-1.4	1998	1.2	1	1.2
Great Lakes/St. Lawrence Lowlands	0.0	1978	-1.0	1998	2.3	1	2.3
Northeastern Forest	0.1	1972	-1.9	1998	2.1	1	2.1
Northwestern Forest	1.4	1950	-2.1	1987	3.0	3	2.3
Prairies	1.2	1950	-2.1	1987	3.1	4	1.8
South British Columbia Mountains	1.4	1955	-1.8	1998	2.0	1	2.0
Pacific Coast	1.1	1955	-1.2	1958	1.6	3	1.2
North British Columbia Mountains/Yukon Territory	1.7	1972	-2.1	1981	2.8	7	1.5
Mackenzie District	1.6	1982	-1.5	1998	3.9	1	3.9
Arctic Tundra	0.8	1972	-2.4	1998	3.3	1	3.3
Arctic Mountains and Fiords	0.3	1972	-1.9	1981	2.2	2	1.9
Canada	**0.7**	**1972**	**-1.8**	**1998**	**2.5**	**1**	**2.5**

Notes:
1. The 1998 data are preliminary.
2. The climate regions of Canada are illustrated in Map 3.3.5.
3. Average change in temperature over the period of record.
4. Difference from the normal temperature.
5. The rank is calculated on series data arranged in descending order, from warmest to coolest values.

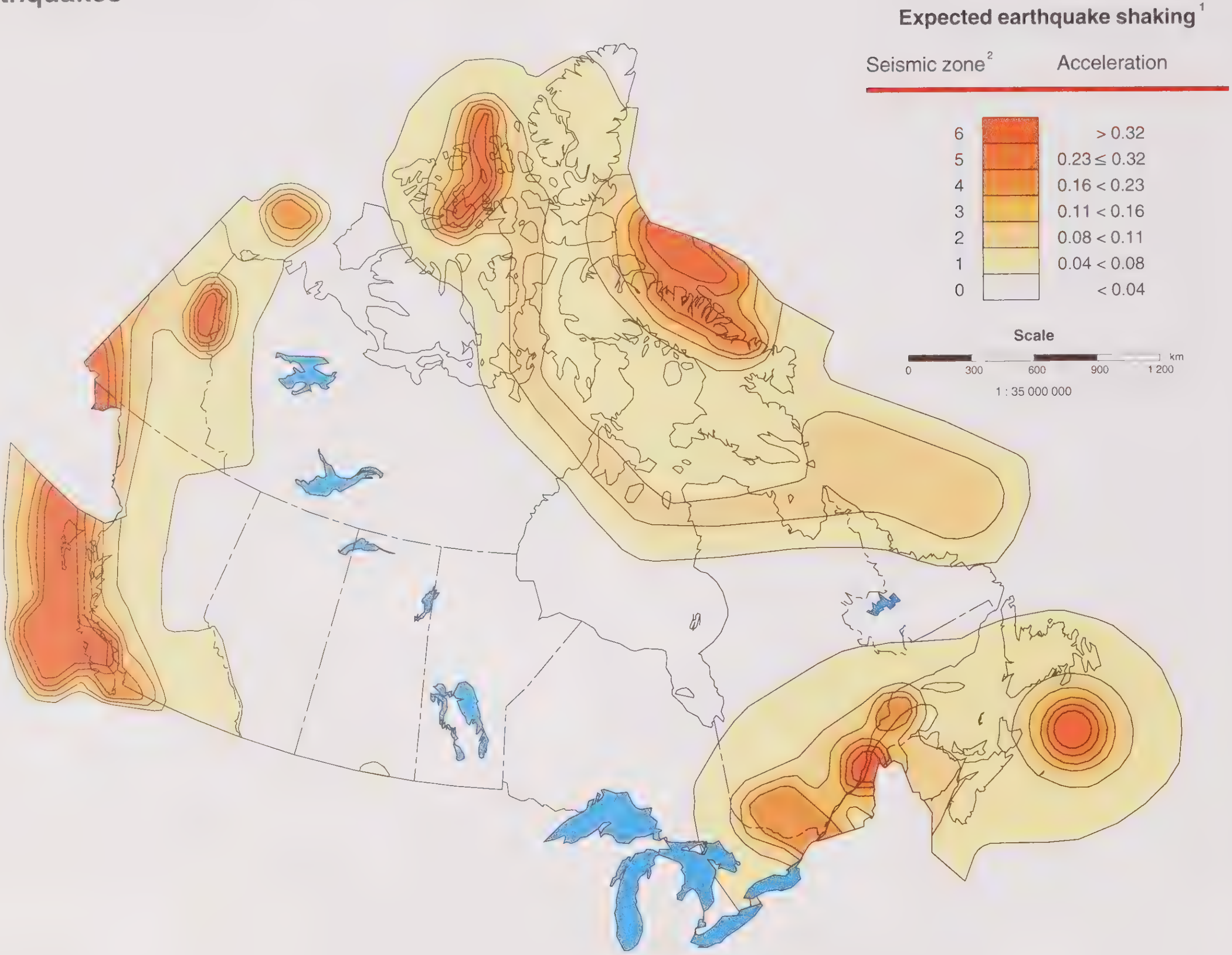
Source:
Environment Canada, Atmospheric Environment Service, Climate Research Branch, 1999, *Climate Trends and Variations Bulletin for Canada*, January, Ottawa.

Map 3.3.5
Canadian Climate Regions

Source:
Environment Canada, Atmospheric Environment Service, Climate Research Branch, 1998, *Climate Trends and Variations Bulletin for Canada*, Ottawa

3.4 Geophysical and meteorological profile

Map 3.4.1
Earthquakes



Notes:
1. Estimated peak horizontal acceleration is expressed as a proportion of gravitational acceleration for each seismic zone.
2. Seismic zones represent the potential risk to small buildings from earthquakes: buildings in zone 0 are at a very little risk; those in zone 6 are at the greatest risk.

Source:
Emergency Preparedness Canada, Natural Resources Canada and Canadian Geographic Enterprises, 1996, *Natural Hazards,* Poster-Map, Ottawa.

Text Box 3.4.1
Atlantic Ocean Tsunami, 1929

On November 18, 1929, a submarine earthquake with a magnitude of 7.2 on the Richter Scale occurred beneath the Grand Banks, south of Newfoundland, causing an underwater landslide. Twelve transatlantic cables were broken in 28 places, while the resulting tsunami wreaked havoc above. The wave was five metres in height when it struck the Burin Peninsula on the south coast of Newfoundland, sweeping away houses and drowning 27 people. This natural disaster caused an estimated $1–2 million in damage.

Sources:
Clague, J.J., 1997, *Tsunamis,* Draft manuscript prepared for the Geological Survey of Canada, National Geological Hazard Synthesis Project, Ottawa.
Natural Resources Canada, Geomatics Canada, *Natural Hazards: Tsunamis,* <http://cgdi.gc.ca/ccatlas/hazardnet/d_tsunami/tsuintro.htm>, (accessed December 22, 1998).

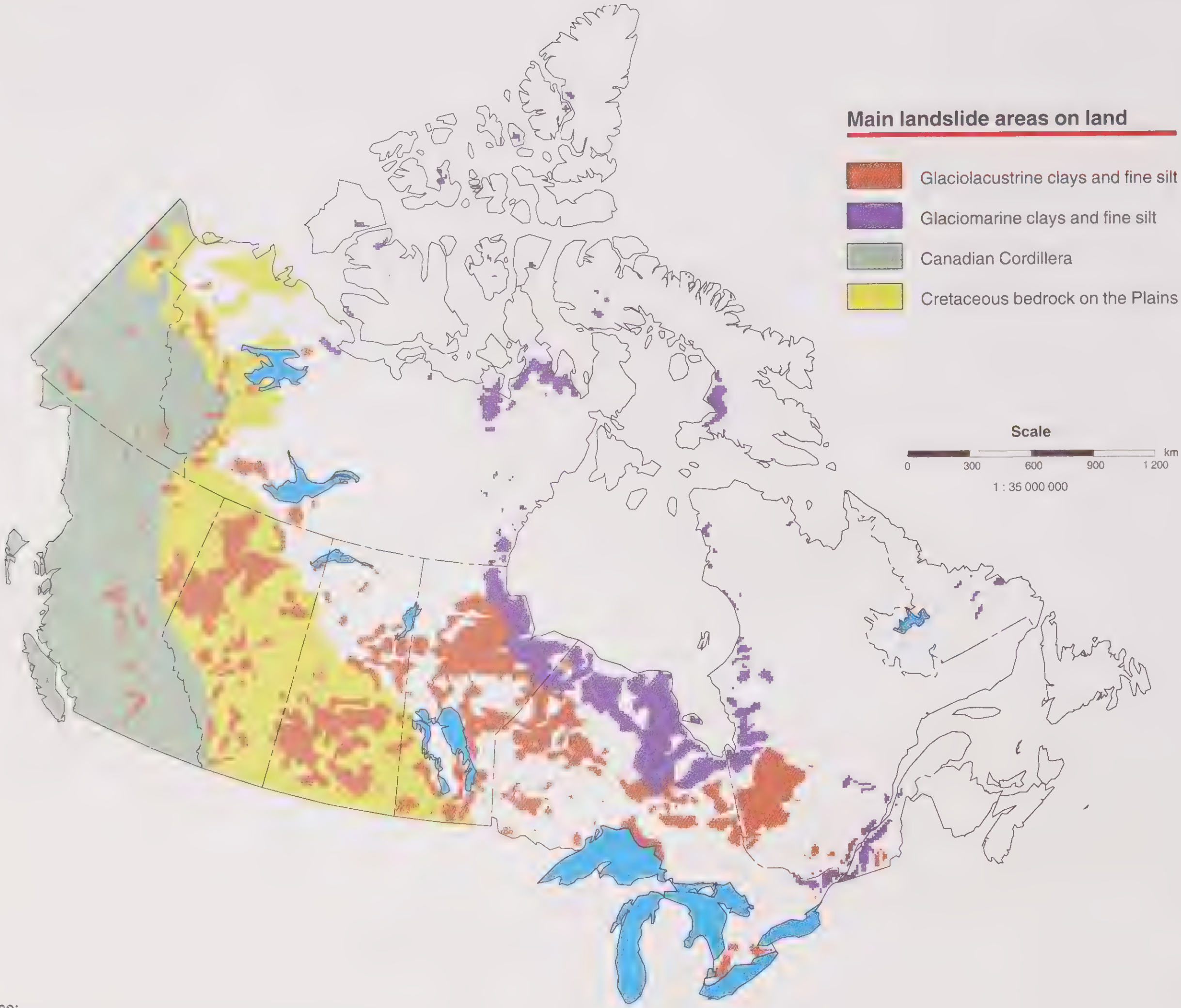
Table 3.4.1
Major Earthquakes, 1663-1998

Year	Location	Magnitude (Richter Scale)	Description
1663	Lower St. Lawrence River, Que.	7.5 to 8.0	many landslides occurred
1700	Cascadia Fault, Pacific Ocean	9.0	megathrust earthquake; tsunamis caused significant damage on Vancouver Island and along east coast of Japan
1732	Montréal, Que.	7.0	one death; many houses damaged
1831	St. Lawrence River Basin	5.5 to 6.0	two earthquakes
1855	Moncton, N.B.	5.5 to 6.0	
1860	Mouth of Saguenay River, Que.	6.5 to 7.0	
1861	Ottawa, Ont.	5.5 to 6.0	minor damage
1870	Mouth of Saguenay River, Que.	7.0	extensive damage to buildings
1872	Vancouver, B.C.	7.5	earthquake east of Vancouver
1897	Montréal, Que.	5.6	
1909	Strait of Georgia, B.C.	6.8	strongly felt in Canada; damage also caused in U.S.
1914	Lanark, Ont.	5.6	
1918	Vancouver Island, B.C.	6.9	widely felt; minor damage near Estevan Point
1924	La Malbaie, Que.	6.1	
1925	Charlevoix-Kamouraska region, Que.	6.7	widely felt; damage along St. Lawrence River and at Québec, Trois-Rivières and Shawinigan
1929	Queen Charlotte Sound, B.C.	7.0	occurred south of Queen Charlotte Islands
1929	Burin Peninsula, Nfld.	7.2	offshore earthquake on Grand Banks caused 'seismic sea wave' to hit Newfoundland coast; 27 drowned
1933	Baffin Bay, N.W.T.	7.3	largest earthquake ever recorded inside Arctic Circle
1935	Timiskaming, Que.	6.2	widely felt; minor damage at Temiscaming, Que., North Bay, Ont. and Mattawa, Ont.
1944	Cornwall, Ont.	5.6	widely felt; major structural damage to buildings
1944	Whitehorse, Y.T.	6.5	
1946	Strait of Georgia, B.C.	7.3	widely felt; damage on east coast of Vancouver Island; one drowning
1949	Queen Charlotte Islands, B.C.	8.1	widely felt over large area of western North America; Canada's largest earthquake; some damage on Islands
1952	Whitehorse, Y.T.	6.0	south of Whitehorse
1953	East-central Yukon	6.5	
1955	East-central Yukon	6.5	
1956	East-central Yukon	6.5	
1956	Vancouver Island, B.C.	6.8	west of Vancouver Island
1956	Queen Charlotte Islands, B.C.	6.5	
1957	Vancouver Island, B.C.	6.8	west of Vancouver Island
1958	Alaska-British Columbia border	7.9	widespread damage and fatalities in Alaska; strongly felt in northern B.C. and Yukon
1960	Queen Charlotte Islands, B.C.	6.7	
1964	Port Alberni, B.C.	8.5	earthquake in Alaska generated 3.6-metre tsunami; $4.7 million in damage along North America's west coast
1970	Queen Charlotte Islands, B.C.	7.4	widely felt
1972	Nootka Island, B.C.	6.2	
1972	Vancouver Island, B.C.	6.2	west of Vancouver Island
1976	Vancouver Island, B.C.	6.7	west of Vancouver Island
1979	Southern Yukon-Alaska border	7.2	strongly felt in Canada; minor damage in Yukon
1980	Vancouver Island, B.C.	6.8	west of Vancouver Island
1982	Miramichi region, N.B.	5.7	a series of major and minor earthquakes; minor property damage
1985	Nahanni, N.W.T.	6.6	felt in Edmonton and Yellowknife; cause of major rock avalanche; minor property damage
1985	Nahanni, N.W.T.	6.9	widely felt in the N.W.T. and northern parts of Alberta and B.C.
1987	British Columbia and Yukon	7.6	strongly felt in Whitehorse
1988	Northwest Territories	6.0	strongly felt in Mackenzie region
1988	Saguenay region, Que.	6.0	felt in 1000-kilometre radius of epicentre; $20 million in damage
1989	Ungava Peninsula, Que.	6.3	strongly felt in northern Quebec; first earthquake in eastern North America to produce surface faulting
1989	Payne Bay, Ungava Peninsula, Que.	5.7	
1990	St. Elias Mountains, Y.T.	5.8	
1991	St. Elias Mountains, Y.T.	5.6	
1991	Vancouver Island, B.C.	5.6	west of Vancouver Island
1992	Vancouver Island, B.C.	6.0	west of Vancouver Island
1992	Vancouver Island, B.C.	6.8	west of Vancouver Island
1992	South of Moresby Island, B.C.	5.8	
1993	South of Moresby Island, B.C.	6.1	
1994	Near Nootka Island, B.C.	5.7	
1996	Southwest of Nootka Island, B.C.	6.3	
1996	Vancouver Island, B.C.	5.7	west of Vancouver Island
1997	Northwest Territories	5.7	occurred 205 kilometres southwest of Repulse Bay
1998	Vancouver Island, B.C.	6.0	west of Vancouver Island

Note:
Earthquakes documented in this table were of Richter Scale magnitude 5.5 or greater. Many other earthquakes of lesser magnitude have occurred in Canada.

Sources:
Jones, Robert L., *Canadian Disasters - An Historical Survey*, <http://www.ott.igs.net/~jonesb/DisasterPaper/disasterpaper.html>, (accessed December 9, 1999).
Energy Mines and Resources Canada, Geophysics and Marine Geoscience Branch, Seismology Section.
Emergency Preparedness Canada, Department of National Defence, *EPC Electronic Disaster Database*, <http://www.epc-pcc.gc.ca/research/epcdatab.html>, (accessed December 9, 1999).
Geological Survey of Canada, *National Earthquake Hazards Program*, <http://www.seismo.nrcan.gc.ca>, (accessed March 30, 1999).

Map 3.4.2
Landslides



Source:
Emergency Preparedness Canada, Natural Resources Canada and Canadian Geographic Enterprises, 1996, *Natural Hazards,* Poster-Map, Ottawa.

Text Box 3.4.2
The Frank Slide, 1903

The Frank Slide, Canada's worst landslide disaster, occurred on the east face of Turtle Mountain in Alberta's southern Rocky Mountains. At 4:10 a.m. on April 29, 1903, a mass of approximately 30 million m^3 of rock detached itself from the upper part of the mountain and crashed to the river below, a vertical distance of over 900 metres. The mass of broken rock swept across the river valley, then climbed 130 metres up the opposite slope. An area of over 2.5 km^2 of the valley floor was buried under as much as 45 metres of rock rubble mixed with mud. At least 70 people were killed in the coal mining town of Frank, which lay at the base of the mountain.

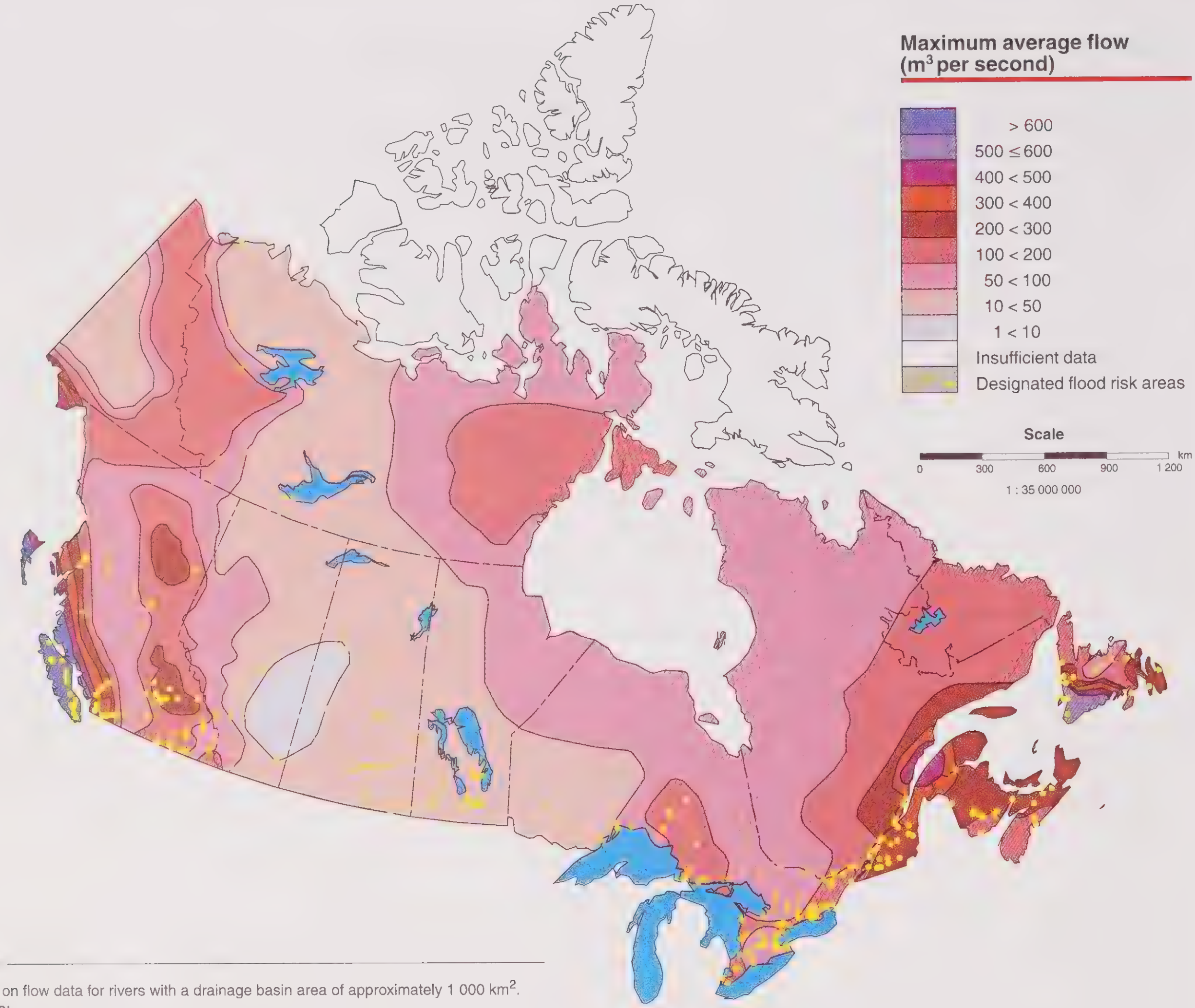
Source:
Natural Resources Canada, Geomatics Canada, *Natural Hazards: Landslides and Avalanches*, <http://cgdi.gc.ca/ccatlas/hazardnet/i_landslide/slidefoto.htm>, (accessed December 30, 1998).

Table 3.4.2
Major Landslides, Snow Avalanches and Related Disasters, 1841-1999

Year	Location	Number of deaths	Description
1841	Québec, Que.	32	rockslide destroyed houses on Champlain Street in Lower Québec
1852	Québec, Que.	7	rockslide destroyed houses on Champlain Street at Cap Blanc
1864	Québec, Que.	4	rockslide destroyed houses on Champlain Street
1877	Ste-Geneviève-de-Batiscan, Que.	5	earthflow overwhelmed mill and adjoining house
1889	Québec, Que.	45	rockslide destroyed houses on Champlain Street in Lower Québec
1891	North Pacific Cannery, B.C.	35	debris flow after heavy rain breached landslide dam; workers' homes overwhelmed
1894	St-Alban, Que.	4	massive landslide carried away farmhouses
1895	St-Luc-de-Vincennes, Que.	5	earthflow destroyed farmhouse
1897	Sheep Creek, B.C.	7	debris flow struck railway maintenance camp
1898	Quesnel Forks, B.C.	3	landslide victims were miners
1903	Frank, Alta.	70	rock avalanche from Turtle Mountain destroyed part of small mining town
1905	Spence's Bridge, B.C.	15	landslide into Thompson River; displacement wave swept victims away
1908	Notre-Dame-de-la-Salette, Que.	33	landslide crashed into row of buildings and carried two houses and half-mile-wide tract of land into Lièvre River
1909	Burnaby, B.C.	22	slump of railway embankment; work train derailed
1910	St-Alphonse-de-Bagotville, Que.	4	landslide from blasting during construction of railway; construction camp buried
1910	Coucoucache, Que.	6	slump of railway embankment; work train derailed
1910	Roger's Pass, B.C.	62	avalanche buried railway crew clearing tracks of snow dumped by previous avalanche
1915	Cooper Mine, Jane Camp, B.C.	57	rock avalanche from above portal of mine swept into mining camp
1921	Britannia Beach, B.C.	37	outburst flood caused by failure of railway fill; more than 50 houses swept away
1922	Elcho Harbour, B.C.	5	debris avalanche caused by heavy rain; logging camp destroyed
1930	Capreol, Ont.	4	slump of railway embankment; passenger train derailed into Vermillion River
1930	Crerar, Ont.	8	slump of railway embankment; freight train derailed
1938	St-Grégoire-de-Montmorency, Que.	4	landslide caused by heavy rain destroyed apartment building
1946	Beattie Mine, Duparquet, Que.	4	landslide debris flowed into mine shaft; victims were underground miners
1955	Nicolet, Que.	3	landslide carried six buildings into crater on shore of Nicolet River; 2 000 evacuated; $10 million in damage
1955	Mount Temple, Lake Louise, Alta.	7	avalanche swept away inexperienced climbers
1957	Prince Rupert, B.C.	7	debris avalanche triggered by heavy rain; three houses buried
1959	Revelstoke, B.C.	4	landslide triggered by highway construction struck house
1960	McBride, B.C.	3	debris flow; victims were highway construction workers
1962	Rivière Toulnustouc, Que.	8	landslide caused by blasting in marine clay; victims were workers
1962	Saguenay Region, Que.	8	landslide
1963	St-Joachim-de-Tourelle, Que.	4	earthflow in leda clay; victims drove into landslide crater
1964	Ramsay Arm, B.C.	5	debris flow caused by heavy rain; logging camp struck
1964	Lac Saint-Jean, Que.	4	landslide
1965	Hope, B.C.	4	massive rock avalanche triggered by local earthquake five days earlier; vehicles buried on B.C. Highway
1965	Ocean Falls, B.C.	7	slush avalanche/debris flow caused by melting snow struck community
1965	Granuc Mine, B.C.	26	avalanche destroyed mining camp; 22 injured
1968	Camp Creek, B.C.	4	debris flow caused by heavy rain struck car on Trans-Canada Highway
1969	Porteau, B.C.	3	rockfall struck car at Porteau Bluffs on Squamish Highway
1971	St-Jean-Vianney, Que.	31	rapid retrogressive flowslide swept away 40 homes; 1 500 evacuated; $17 million in damage
1971	Fraser Canyon, B.C.	3	rockfall derailed CNR train
1972	Michel, B.C.	3	debris flow from coal mine waste dump; CPR maintenance crew struck
1973	Harbour Breton, Nfld.	4	debris avalanche; four houses swept into harbour and destroyed
1974	Terrace, B.C.	7	avalanche buried service station and motel
1975	Devastation Glacier, B.C.	4	massive rock avalanche buried geophysical survey crew
1976	Kootenay Pass, B.C.	3	avalanche
1979	British Columbia	7	avalanche killed seven heli-skiers in Purcell range southwest of Golden, B.C.
1980	Belmoral Mine, Val-d'Or, Que.	8	flow of lacustrine sediments into mine workings triggered by cave-in of mine roof
1981	Highway 99, B.C.	9	debris flow destroyed M-Creek Bridge during heavy rain; four vehicles plunged into creek
1981	Golden, B.C.	3	avalanche near Conrad Icefield, west of Golden; victims were heli-skiers
1986	Valemont, B.C.	4	avalanche buried snowmobilers
1987	Blue River, B.C.	7	avalanche victims were six American heli-skiers and Canadian guide
1990	Joe Rich, B.C.	3	debris avalanche caused by heavy rain and flooding destroyed house
1990	Banff, Alta.	4	avalanche in Banff National Park; victims were cross-country skiers from Calgary
1991	Purcell Mountains, B.C.	9	massive avalanche in Bugaboo Glacier Provincial Park; victims were heli-skiers
1997	Monashee Mountains, B.C.	4	avalanche victims included heli-ski operator
1997	Calgary, Alta.	4	avalanche victims were Calgary teenagers, skiing and snowboarding west of Calgary
1998	Kaslo, B.C.	6	avalanche near Woodbury Glacier in Kokanee Glacier Park; buried victims were skiers
1999	Kangiqsualujjuaq, Que.	9	avalanche swept into school gymnasium; 25 injured, including 10 children

Note:
The main criterion for inclusion of an event in this table is significant impact on people. Significant events are not included if they caused little damage or occurred in isolated areas.
Sources:
Evans, S.G., 1999, *Landslide Disasters in Canada (1840-1998)*, Geological Survey of Canada, Open File 3712, Ottawa.
Jamieson, B. and G.R. Brooks, 1998, *Regional snow avalanche activity and known fatal avalanche accidents for Canada (1863 to June 1997)*, Geological Survey of Canada, Open File 3592, Ottawa.
Jones, Robert L., *Canadian Disasters - An Historical Survey*, <http://www.ott.igs.net/~jonesb/DisasterPaper/disasterpaper.html>, (accessed December 9, 1999).
Emergency Preparedness Canada, Department of National Defence, *EPC Electronic Disaster Database*, <http://www.epc-pcc.gc.ca/research/epcdatab.html>, (accessed December 9, 1999).

Map 3.4.3
Average Annual Peak River Flow



Note:
Based on flow data for rivers with a drainage basin area of approximately 1 000 km^2.
Source:
Natural Resources Canada, Geomatics Canada, *Natural Hazards: Peak Water Flow and Flood Risk Areas,* <http://cgdi.gc.ca/ccatlas/hazardnet/g_floods/fldmap.htm>, (accessed December 22, 1998).

Text Box 3.4.3
Saguenay River Flood of 1996 and Red River Flood of 1997

The flooding and mudslides of Quebec's Saguenay River Valley in July 1996 produced the largest overland deluge in Canada this century. As much as 280 millimetres of rain was recorded by climatologists, much of it falling during a 36-hour period. The Saguenay Flood triggered a surge of water, rocks, trees and mud that killed 10 people and forced 12 000 residents from their homes. Much of the region's infrastructure—including roads, bridges and delivery systems for power and water—simply disappeared.

The following year, Manitoba was hit by a flood as the Red River overflowed its banks to cover nearly 2 000 km^2 of the Red River valley. Normally 180 metres wide, the river spread to a girth of 30 kilometres. The flood forced more than 28 000 people from their homes and unofficial estimates of total damage were in the area of $500 million.

Source:
Phillips, D., 1998, *Blame It on the Weather,* Key Porter Books Limited, Toronto.

Table 3.4.3
Major Floods, 1826-1998

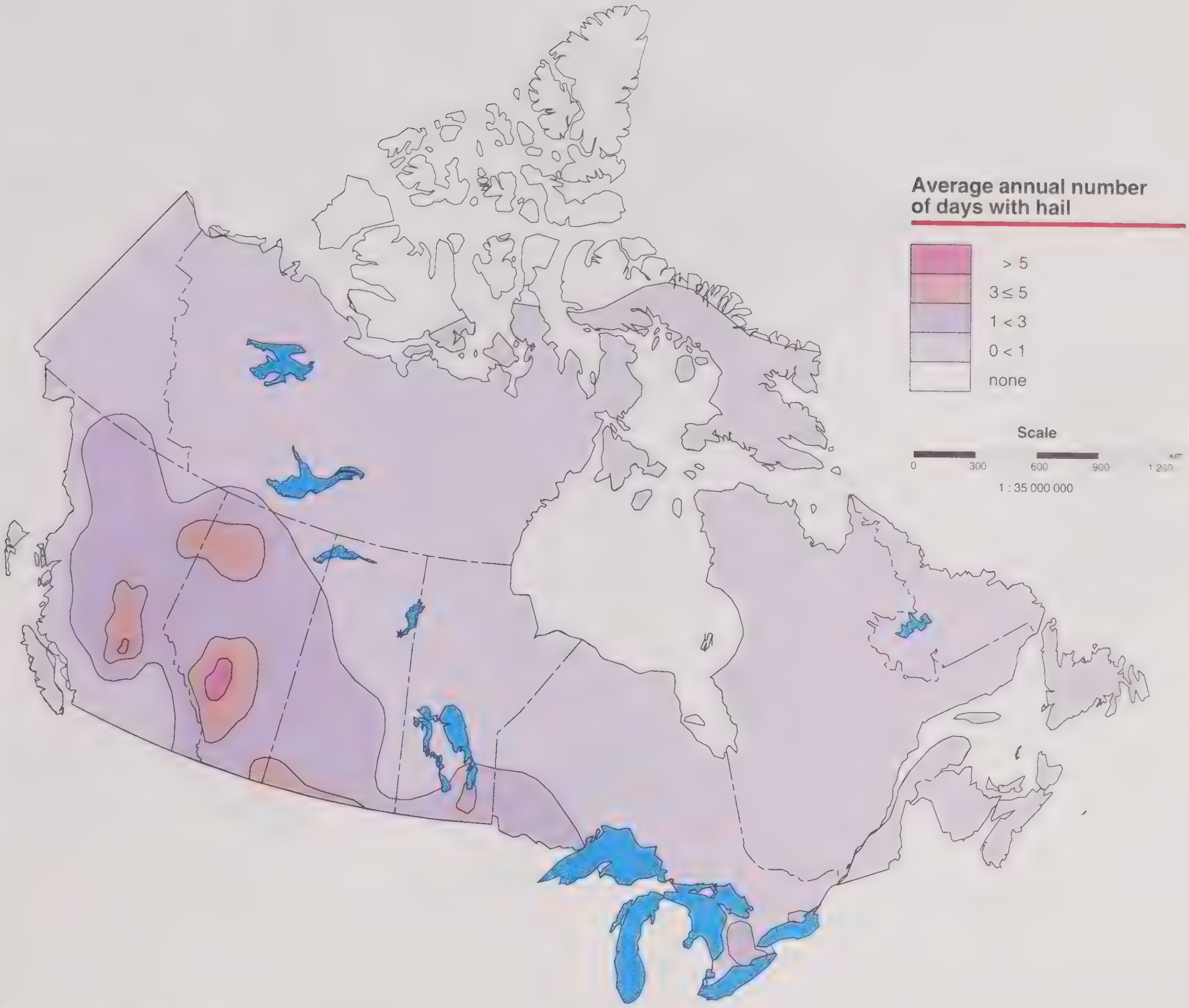
Year	Location	Number of deaths	Description
1826	Red River, Man.	-	river 4 metres above normal with spring run-off; widespread damage
1865	Sorel and Trois-Rivières, Que.	45	St. Lawrence River flooding
1878	Toronto, Ont.	-	heavy summer rain (13 centimetres in 7.5 hours) caused Don River to overflow; extensive damage
1883	Lake Ontario	18	flash flood
1894	Fraser River, B.C.	-	heavy spring run-off; widespread damage
1902	Saint John River, N.B.	2	heavy rain and warm temperatures raised water levels; extensive province-wide damage estimated at $25 000
1909	New Brunswick	1	floods caused extensive damage to highway bridges and roads
1913	Amherst County, N.S.	2	heavy rain; widespread damage
1915	Edmonton, Alta.	-	heavy summer rain caused North Saskatchewan River to flood; widespread damage
1917	Chaudière River, Que.	-	heavy rain; widespread damage
1923	New Brunswick	2	snowmelt, ice jams and heavy rainfall; damage reached $3.75 million
1928	Estrie River, Que.	4	spring run-off; widespread damage
1928	Ontario and Quebec	3	Rideau, Chaudière and Quyon Rivers overflowed banks
1933	New Brunswick and eastern Quebec	3	snowmelt, heavy rain and ice jams
1933	Southern New Brunswick	7	heavy autumn rain; extensive damage to roads, dams and bridges; drowning victims were stream drivers
1936	New Brunswick	-	spring run-off washed out many bridges and dams; damage estimated at $1.9 million
1941	Newfoundland	2	torrential rain; victims drowned when dam broke
1947	Kings County, N.B.	2	rain, mild temperatures and ice jams; victims drowned near Elgin, Albert County
1947	Saint John River, N.B.	2	heavy rain and snowmelt; 100 evacuated; victims killed in train wreck near Bristol
1948	Southern and eastern Ontario	-	flooding in Lake St. Clair region, Toronto area and Rideau River area; damage estimated at $10 million
1948	St. John's, Nfld.	1	torrential rain caused mudslides; three houses collapsed when hit
1948	Fraser River, B.C.	10	10% of Fraser Valley flooded; 200 families homeless; 3 000 buildings destroyed; damage estimated at $15 million
1950	Red River, Man.	1	heavy rain and snowmelt flooded 1 760 km^2; 107 000 Winnipeg residents evacuated; $100 million in damage
1955	Saskatchewan and Manitoba	-	spring run-off and heavy rain; extensive damage
1957	Bécancour, Que.	4	heavy summer rain; widespread damage
1961	Timmins, Ont.	5	severe thunderstorm; extensive damage
1961	Saint John River, N.B.	1	widespread flooding in late May; $4 million in damage; victim drowned
1964	Goulds, Nfld.	1	heavy rain; 2-year-old drowned in rising stream
1964	Alberta	21	heavy rain in the Oldman and Milk river basins in Alberta; resulting deaths occurred in Montana
1965	St. Lawrence River, Que.	20	ice jam caused flood 20 kilometres downstream from Montréal; several communities reported damage
1966	Red River, Man.	-	severe flooding in the Winnipeg area; $12.2 million in flood disaster assistance
1966	St. Lawrence River, Que.	5	exceptional fall flood on north bank of St. Lawrence River; damage estimated at $3 million
1969	Saint John River, N.B.	1	spring run-off; child victim drowned in river at Iroquois, Madawaska County
1970	Saint John River, N.B.	3	snowmelt, ice jams and heavy rain; $4.63 million in damage estimated
1971	Halifax, N.S.	-	heavy summer rain from Hurricane Beth; widespread damage
1972	Quebec	-	serious flooding throughout province from mid-April to beginning of June; estimated $22 million in damage
1972	Newfoundland	1	spring run-off and rain affected communities on the Port au Prince Peninsula and surrounding area
1972	Fraser River, B.C.	-	spring run-off and heavy rain; extensive damage amounting to $10 million
1972	Peace River, Alta.	-	heavy summer rain; extensive crop and property damage
1972	Western end of Lake Erie, Ont.	-	wind-driven waves; extensive damage
1973	Saint John River, N.B.	-	snowmelt run-off and heavy rain; $11.9 million in damage
1974	North-central Alberta	-	$10 million in damage during April and May
1974	Cambridge, Ont.	-	flooding along Grand River caused $7-10 million in damage; many evacuated
1974	Quebec	-	province-wide flooding affected over 300 municipalities; 10 000 evacuated; damage estimated at $60 million
1974	Saskatchewan and Alberta	-	spring run-off; extensive damage
1974	Red River, Man.	-	severe flooding on almost all rivers and river systems; $14.5 million in damage; many people evacuated
1976	Newfoundland	2	spring run-off caused flooding of Exploits River; two people drowned; highway repairs estimated at $500 000
1976	Perth-Andover, N.B.	2	cyclonic storms and high snowmelt rate caused severe flooding; 400 evacuated; $2 million in damage
1976	Manitoba	-	record flooding on Assiniboine River; $4.5 million in damage
1976	Nova Scotia	-	heavy spring rain; extensive damage
1976	Quebec	-	spring run-off and heavy rain caused province-wide flooding; damage estimated at $20 million
1978	Newfoundland	-	floods cause $5.2 million in damage
1978	Northwest British Columbia	-	spring run-off; extensive damage
1979	Central Ontario	-	flooding around Lake Nipissing and along Mississagi, Blind and Mattagami rivers; $12 million in damage
1979	Red River region, Manitoba	-	major flood; $18.6 million in damage; 10 000 evacuated
1979	Dawson, Y.T.	-	spring run-off and ice jam on Yukon River caused water to rise 2 metres; 80% of Dawson's buildings flooded
1979	New Brunswick	1	snowmelt, ice jams and heavy rain caused two flooding events; $2 million in damage for each
1980	Saint-Hubert, Que.	2	severe thunderstorm dropped 40 millimetres of rain in 30 minutes
1980	Port Hope, Ont.	-	spring run-off and heavy rain caused Ganaraska River to flood; damage estimated at $11 million
1980	British Columbia	-	evacuation after week of heavy rain near Vancouver in December
1980	Squamish River, B.C.	-	heavy rain and melting snow; $13 million in damage
1981	South coast, B.C.	-	heavy rain caused flooding and landslides; extensive damage
1981	Windsor, Ont.	-	heavy rain caused Turkey Creek to flood; extensive damage to southeastern section of city
1981	Edmonton, Alta.	4	thunderstorm dropped 56 millimetres of rain in less than three hours; washouts and mudslides
1982	Aklavik, N.W.T.	-	spring run-off and ice jams; extensive damage
1983	Montréal area, Que.	-	heavy rain caused several rivers to overflow banks; damage estimated at $8 million
1983	Gaspé, Que.	-	high tides; severe winter storm; extensive damage

Table 3.4.3
Major Floods, 1826-1998 (continued)

Year	Location	Number of deaths	Description
1983	Regina, Sask.	-	severe flooding from intense rain overloading sewer system; damage estimated at $60 million
1983	Newfoundland	-	heavy rain caused dam to burst on Exploits River; 500 evacuated; damage estimated at $34 million
1983	Gaspé, Que.	-	high tides and violent winds caused flooding along Gaspésie and Gulf of St. Lawrence shores; $12 million in damage
1984	Nova Scotia	1	described as worst flood in the Truro area in 50 years; victim died from fumes while pumping out basement
1984	Saint John River, N.B.	1	rain, mild temperatures and snowmelt; several houses inundated; victim drowned
1984	Newfoundland	-	ice jams; heavy spring rain; extensive damage, including sinking of fishing boats
1984	Lower Fraser River, B.C.	-	heavy rain and snowmelt; roads, bridge and sections of railway track washed out
1984	Pemberton area, B.C.	1	persistent heavy rain caused severe flooding; 3 000 evacuated; estimated $3.1 million in damage
1985	Lake Erie, Ont.	-	two storms destroyed cottages and washed out roads; damage estimated at $8.1 million
1985	Southern Ontario	-	heavy spring rain and melting snow flooded 5 600 hectares; extensive damage
1985	Hay River, N.W.T	-	ice jams and spring run-off; minor damage; one injury
1986	Winisk, Ont.	2	community virtually destroyed when river overflowed banks; 129 residents airlifted to safety
1986	Saskatchewan and Alberta	1	heavy summer rain; extensive damage to roads, homes and crops estimated at $28.3 million
1986	Central Alberta	-	July flooding damaged 1 500 houses; costs in excess of $30 million
1987	Perth-Andover, N.B.	-	snowmelt and heavy rain caused severe flooding; 300 evacuated; $11 million in damage
1987	Montréal, Que.	2	severe thunderstorm caused flash flood with 100 millimetres of rain in one hour; damage estimated at $94 million
1987	Québec, Que.	-	heavy spring rain and snowmelt; 300 evacuated; damage estimated at $12 million
1988	Southwestern Northwest Territories	-	two severe floods in Liard and Mackenzie river basins; $6 million in damage, mainly to highways and oil line
1988	Lesser Slave Lake, Alta.	2	flood caused $15 million in damage
1989	Essex County, Ont.	-	widespread flooding caused by 450 millimetres of rain in a 30-hour period; $35 million in damage to agricultural areas
1990	Southern British Columbia	4	washouts and mudslides closed sections of three highways; damage estimated at $10 million
1990	Southwestern British Columbia	-	heavy rain caused widespread flooding; 309 evacuated; damage estimated at $5-10 million
1991	Chaudière River, Que.	-	record high flood levels damaged many homes and businesses; 1 000 evacuated; $5-10 million in damage
1992	Peace River, Alta.	-	extensive flooding; $3 million in damage; 3 800 evacuated
1993	Winnipeg, Man.	-	heavy summer rain; extensive damage to homes, power lines and agricultural lands estimated at $500 million
1993	Southwestern Manitoba	-	prolonged rain resulted in severe flooding in several rural municipalities; extensive damage estimated at $20 million
1995	Southern Alberta	-	record rainfall caused 'once-in-100-year floods' on more than a dozen rivers; 4 000 evacuated from Medicine Hat
1996	Saguenay Region, Que.	10	Saguenay River flooding caused severe damage to region; 2 000 families left homeless
1997	British Columbia	-	flooding in Terrace, Kamloops, Prince George and Nelson areas; $4 million in damage; $10 million in response costs
1997	Durham, Ont.	-	Saugeen River flooding; 200 evacuated; some businesses and schools closed
1997	Peace River, Alta.	-	ice jams on Peace River backed up on Heart River; 4 000 evacuated
1997	Winnipeg, Man.	1-3	Assiniboine, Red and Winnipeg rivers flooded; 28 000 evacuated
1997	Southern British Columbia	-	steady precipitation and ground saturation; extensive damage to agricultural lands
1998	Ontario and Quebec	-	warm weather and thunderstorms caused spring flooding; 3 757 evacuated

Notes:
The main criterion for inclusion of floods in this table is significant impact on people. Some significant events are not included if they caused little damage or occurred in isolated areas.
Unless otherwise specified, value of damage is expressed in dollars of the year of the disaster.
Sources:
Emergency Preparedness Canada, Department of National Defence, *EPC Electronic Disaster Database*, <http://www.epc-pcc.gc.ca/research/epcdatab.html>, (accessed December 9, 1999).
Environment Canada, Inland Waters Directorate, Water Planning and Management Branch.
Jones, Robert L., *Canadian Disasters - An Historical Survey*, <http://www.ott.igs.net/~jonesb/DisasterPaper/disasterpaper.html>, (accessed December 9, 1999).

Map 3.4.4
Hail



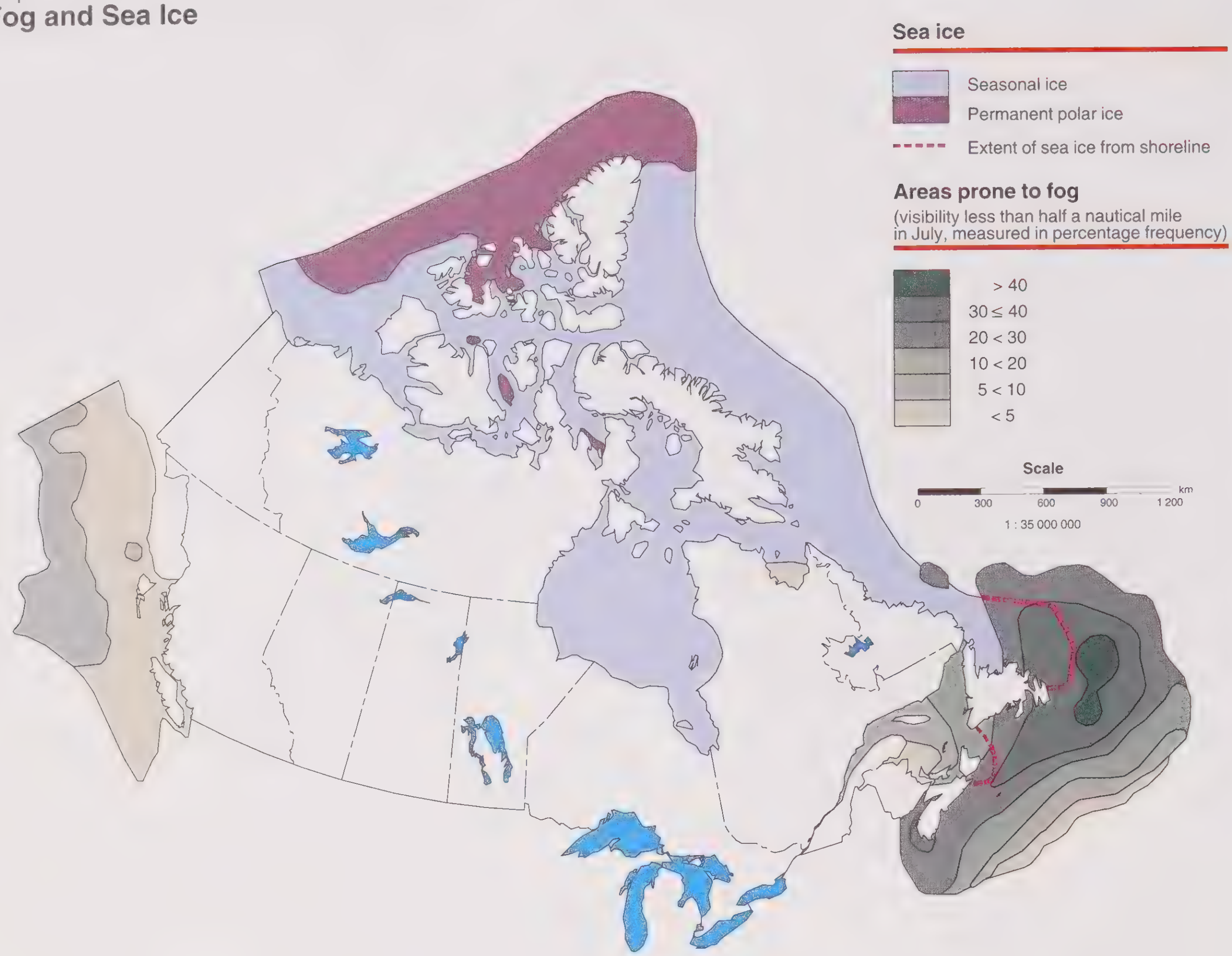
Source:
Emergency Preparedness Canada, Natural Resources Canada and Canadian Geographic Enterprises, 1996, *Natural Hazards*, Poster-Map, Ottawa.

Text Box 3.4.4
Calgary Hailstorm, 1991

Hail is precipitation falling in the form of ice pellets at least five millimetres in diameter. In Canada, hailstorms occur most frequently in the western provinces and southwestern Ontario. The Calgary hailstorm of September 7, 1991 was the worst in Canadian history in terms of paid insurance claims. Although the hail portion of an average storm lasts from 6 to 10 minutes, hail fell for a full 30 minutes during this storm and resulted in 116 000 claims. An estimated $237 million was claimed in property damage and $150 million in vehicle damage.

Source:
Emergency Preparedness Canada, Natural Resources Canada and Canadian Geographic Enterprises, 1996, *Natural Hazards*, Poster-Map, Ottawa.

Map 3.4.5
Fog and Sea Ice



Source:
Natural Resources Canada, Geomatics Canada, *Natural Hazards: Fog and Sea Ice,* <http://cgdi.gc.ca/ccatlas/hazardnet/h_oceandanger/fogice_map.htm>, (accessed December 22, 1998).

Text Box 3.4.5
Hazards at Sea: Icebergs and Fog

Despite precautionary measures such as radar, and monitoring by Canadian Ice Services and the International Ice Patrol, sea travel can still be made dangerous by icebergs. In July 1981, the 900-tonne Canadian survey ship *Arctic Explorer* struck an iceberg off Newfoundland and sank in 20 minutes. Thirteen crewmen died while 19 others drifted for two days in a life raft.

Fog, which can reduce visibility on land or water to almost nil, poses a threat to all forms of transportation. In May 1914 a fog-related collision between the Canadian Pacific's vessel *Empress of Ireland* and the Norwegian coal ship *Storstadt* occurred in the St. Lawrence River near Rimouski, Quebec. More than 1 000 people perished in this collision, the worst maritime disaster in Canadian history. The Captain of the *Empress of Ireland* told an inquest that he had brought his ship to a halt and was waiting for clearer weather when another ship appeared out of the fog, less than a ship's length away, bearing directly upon him.

Source:
Emergency Preparedness Canada, Natural Resources Canada and Canadian Geographic Enterprises, 1996, *Natural Hazards,* Poster-Map, Ottawa.

Table 3.4.4
Major Storms, 1583-1998

Year	Location	Number of deaths	Description
1583	Sable Island, N.S.	85	ship *Delight* wrecked
1711	Québec, Que.	884	fleet of ships ran aground in fog
1746	Sable Island, N.S.	200-300	four French warships sank
1775	Grand Banks, Nfld.	4 000	hurricane hits Grand Banks area
1783	Eastern Lake Ontario	190	sloop *Ontario* sank
1799	Sable Island, N.S.	40	vessel *Francis* wrecked
1807	Newcastle, Ont.	20	schooner *Speedy* lost in Lake Ontario
1813	Lake Ontario	53	ships *Hamilton* and *Scourge* sank
1814	St. Paul's Island, N.S.	799	vessel *Sovereign* wrecked
1828	Newfoundland	50	brig *Dispatch* ran aground off south coast
1844	Lake Ontario and Lake Erie	200	many vessels lost
1847	Newfoundland	300	hurricane
1851	Prince Edward Island	150-300	70 fishing vessels sank in gale
1856	St. Paul's Island, N.S.	72	Irish ship ran aground
1860	Sable Island, N.S.	30	American ship *Argo* wrecked
1860	Sable Island, N.S.	205	vessel *Hungarian* wrecked
1863	Cape Race, Nfld.	238	vessel *Anglo-Saxon* wrecked
1869	Maritimes	-	extensive damage to property and utilities from legendary Saxby Gale
1870	Nova Scotia	191	vessel *City of Boston* disappeared
1872	Toronto, Ont.	-	greatest two-day snowfall on record (58.4 centimetres), December 25-26
1873	Cape Breton Island, N.S.	360-380	hurricane destroyed over 1 200 boats, August 25
1879	Georgian Bay	24	steamer *Waubino* sank in gale
1882	Georgian Bay	126	vessel *Asia* sank
1885	Labrador	70	89 ships sank in October gale
1885	Ottawa, Ont.	-	communications paralyzed by heavy snow (108 centimetres) followed by rain (50 millimetres), April 2-6
1885	Lake Superior	48	CPR ship *Algoma* sank
1889	Niagara Falls, Ont.	-	Niagara suspension bridge blown down in snowstorm, January 9
1898	Nova Scotia	545	vessels *La Bourgogne* and *Cromartyshire* collided
1899	Yarmouth, N.S.	36	vessel *City of Monticello* wrecked
1906	Vancouver Island, B.C.	126	vessel *Valencia* wrecked
1908	Newfoundland	48	sealers from vessel *Greenland* froze on ice
1913	Lower Great Lakes	270	34 ships sank in storm
1914	Newfoundland	173	vessel *Southern Cross* disappeared
1914	Newfoundland	77	four sealing ships caught in ice
1914	Rimouski, Que.	1 014	ships *Empress of Ireland* and *Storstadt* collided
1918	British Columbia	343	vessel *Princess Sophia* ran aground
1930	St. Lawrence River	30	freighter *John B. King* (carrying explosives) exploded and sank when struck by lightning
1932	Maritimes	-	tropical storm with high winds and rain, September 17; extensive crop and property damage
1935	Southern British Columbia	-	heavy snowstorm (44 centimetres) hit January 19; extensive damage; roads impassable
1935	Newfoundland	50	severe storm destroyed villages, August 25
1940	Great Lakes	69	three ships wrecked in storm
1941	Prairies	76	severe seven-hour blizzard produced winds exceeding 100 km/h in southern Prairie provinces and northern U.S.
1942	Newfoundland	204	vessels *Truxton* and *Pollux* ran aground
1944	Southern and eastern Ontario and Quebec	-	heavy snowstorm (52 centimetres), December 11; roads impassable
1946	Okanagan Valley, B.C.	-	extensive fruit crop damage from hailstorm, July 29; hailstones 5 centimetres in diameter; $2 million in damages
1953	Lake Superior	17	freighter sank in high winds
1954	Southern Ontario	83	Hurricane Hazel; widespread wind and flood damage estimated at $25 million
1956	Mt. Slesse, B.C.	62	aircraft crashed into Mt. Slesse during storm
1956	Elkhorn and Crystal City, Man.	-	extensive crop and property damage from hailstorm and tornadoes, August 16
1958	St. John's, Nfld.	-	freezing rain lasted 43 hours, February 27-March 2; major power disruptions
1959	St. John's, Nfld.	6	heavy snow paralyzed transportation and communications, February 16
1959	Listowel, Ont.	8	heavy snow followed by rain, February 28; arena roof collapsed
1959	Escuminac, N.B.	35	22 fishing boats sank
1959	Nova Scotia	33	victims of unnamed hurricane were mostly lobster fishermen; considerable property damage
1961	Montréal, Que.	-	ice storm with high winds (>120 km/h), February 25; damage estimated at $7 million
1962	Nova Scotia	-	Hurricane Daisy, October 7-8; $2 million in damage
1962	West Coast, B.C.	7	remnants of Typhoon Freda struck Pacific Coast, October 12; estimated $10 million in damage
1964	Southern Prairies	3	thousands of animals died in heavy snows, 90-km/h winds and -34°C temperatures of 'Great Blizzard'
1964	Maritimes	23	severe winter storm; eight injuries reported
1966	Winnipeg, Man.	-	heavy snow (36 centimetres) and high winds (>120 km/h) paralyzed the city, March 4
1966	Lake Huron	28	ore carrier *D.L. Morrell* sank in storm
1967	Southern Alberta	-	heavy snowfall (205 centimetres), April 17-20; thousands of cattle starved
1968	Cape Breton Island, N.S.	1	remnants of Hurricane Gladys produced up to 90 millimetres of rain in some areas
1969	Montréal, Que.	15	snowstorm; 70 centimetres of snow in 60 hours
1969	Edmonton, Alta.	-	hailstorms and tornadoes, August 4; $17 million in damage to city and surrounding area
1970	Turtle Creek, N.B.	-	125 cm of snow, December 24-28
1971	Montréal, Que	-	heavy snow (43 centimetres) and high winds (>100 km/h) paralyzed the city, March 4

Table 3.4.4
Major Storms, 1583-1998 (continued)

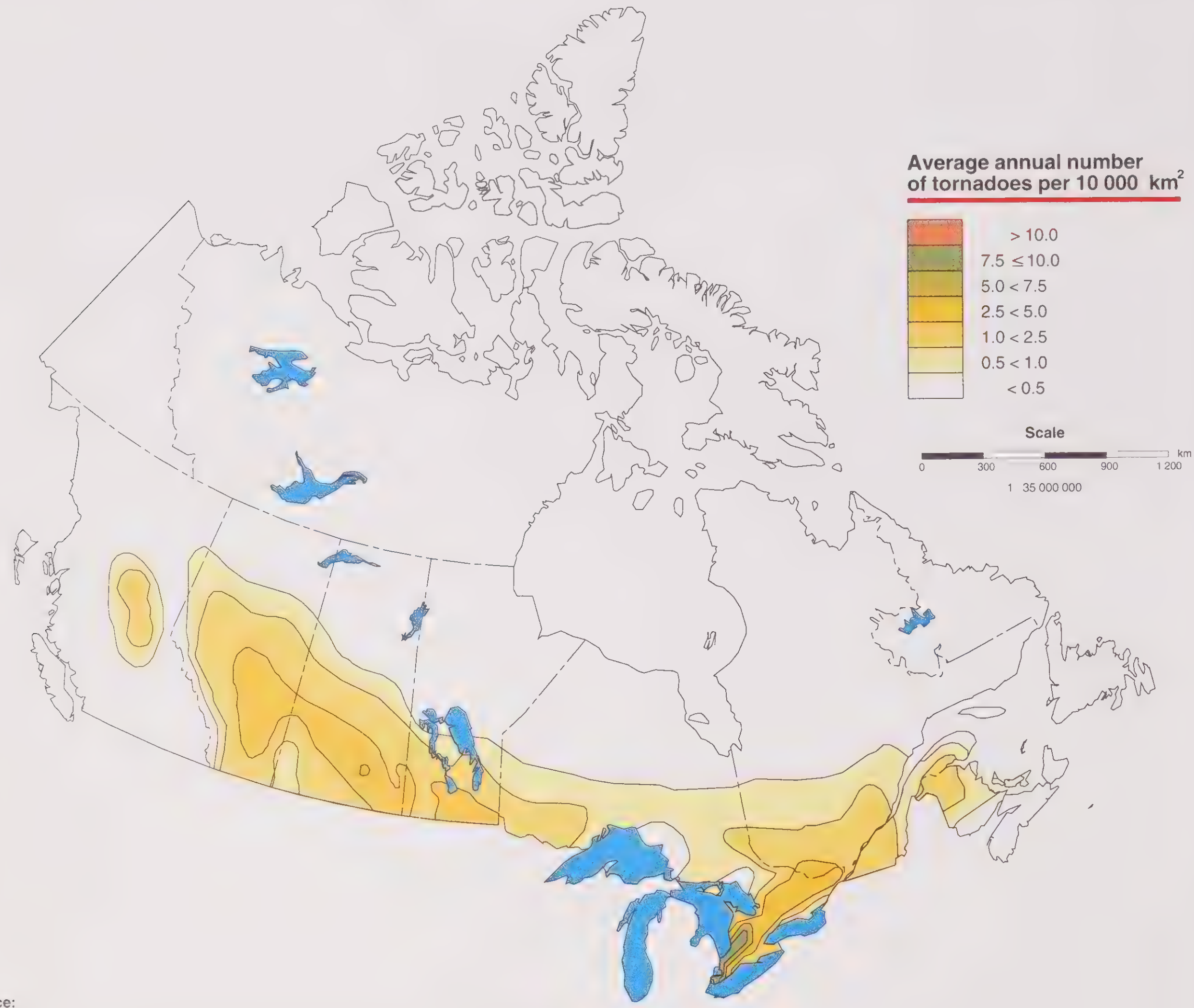
Year	Location	Number of deaths	Description
1971	St. Jean-Vianney, Que.	31	heavy rainstorm caused crater to develop
1971	Western Prairies	-	hailstorm with 500 kilometre-long path; $20 million in damage
1971	Nova Scotia	-	Hurricane Beth, August 15-16; flood damage estimated at $3.5-5.1 million
1973	Barrie, Ont.	12	blizzard, March 18; 43 injuries; property damage estimated at $17 million
1973	Cedoux, Sask.	-	hailstorm; produced largest hailstone in Canada (290 grams and 114 millimetres in diameter); $10 million damage
1974	Newfoundland	-	ice conditions; $5.1 million in damage
1975	Vancouver Island, B.C.	14	March storm
1975	Lake Superior	29	vessel *Edmund Fitzgerald* wrecked
1975	Eastern Ontario	-	heavy snow and high winds isolated several communities, April 2-5; extensive damage
1975	Saskatchewan	-	thunderstorms with high winds, June 25; extensive crop damage
1976	Maritimes	-	heavy rain and snowstorm, February 2; power and transportation disruptions; damage estimated at $10 million
1977	Prince Edward County, Ont.	-	heavy snow paralyzed communities and disrupted transportation, January 28
1978	Winnipeg, Man.	-	hailstorm, May 25; $20 million in damage
1978	St. John's, Nfld.	-	45 millimetres of rain and winds of 115 km/h recorded during Hurricane Ella, September 5
1978	Southern Ontario	12	heavy snow and high winds (>115 km/h); extensive damage
1978	Cranbrook, B.C.	42	PWA 737 crashed in snowstorm
1979	St. Hyacinthe, Que.	11	bus crashed into highway overpass
1979	Frobisher Bay, N.W.T.	-	blizzard cut off community, February 8-17
1979	British Columbia	..	ship *Lee Wang Zin* capsized off Queen Charlotte Islands, December 25
1980	Kelowna, B.C.	-	thunderstorm and high winds (>139 km/h) uprooted trees and caused power failures, April 14
1980	Southwestern B.C.	3	severe blizzard caused heavy snows, strong winds and record low temperatures, December 4
1981	Calgary, Alta.	2	hailstorm over area of 100 km^2, July 28; insured damage estimated at $150 million
1982	Labrador City, Nfld.	3	winter storm; 2 000 evacuated; mayor declared state of emergency
1982	Newfoundland	84	heavy snowstorm and high winds; drilling rig *Ocean Ranger* sank off Newfoundland
1982	Prince Edward Island and Magdalen Islands, Que.	-	many communities isolated for days during succession of severe storms, February 22-26
1983	Regina, Sask. and Edmonton, Alta.	-	June 24 storm caused flooding; $25 million in damage
1983	Edmonton, Alta.	-	August 3 storm caused $22 million in damage
1983	Winnipeg, Man.	-	freezing rain disrupted transportation, March 6; damage estimated at $2 million
1983	Southern Quebec	-	freezing rain, December 13; major power disruptions throughout region
1984	Newfoundland	-	April 11 ice storm; 200 000 Avalon Peninsula residents without heat or light for days; $3.2 million in damage
1984	Bruce County, Ont.	-	windstorm, April 30; $39 million in damage
1984	Eastern Ontario & western Quebec	1	severe storm destroyed 300 houses; 38 injured
1984	Alberta	-	October snowstorm caused significant loss in unharvested crops; $100 million in damage
1984	West Coast, B.C.	5	storm from remnants of Typhoon Odgen, October 11-12; victims were fishermen
1985	Windsor-Leamington, Ont.	-	hailstorm, May 30; $30-40 million in damage
1985	St. Sylvère, Que.	-	tornado, June 19; three injuries and extensive damage
1985	Mississauga, Ont.	-	tornado, July 7; 10 injuries and minor damage
1985	New Liskeard, Ont.	-	hailstorm, July 21; extensive crop damage
1985	Southwestern Quebec	-	hailstorm, July 30; extensive crop and property damage
1986	Montréal, Que.	-	hailstorm, May 26; $90 million in damage
1986	Southern and eastern Ontario	-	hailstorm, June 16; extensive crop and property damage
1986	Southern Ontario	-	hailstorm, August 2; extensive crop damage
1986	Winnipeg, Man.	-	35.8 centimetres of snow from blizzard; snow removal costs approached $3 million
1986	Ottawa, Ont.	-	severe ice storm across Ottawa Valley, December 25; transportation and utilities affected
1987	Eastern Canada	8	snowstorm with high winds, March 17; traffic disrupted; schools and businesses closed
1987	Cape Race, Nfld.	34	trawler *Hosanna* sank 400 kilometres off coast
1987	Peace River District	-	heavy summer rain damaged crops and roads in Alberta and B.C.
1987	Montréal, Que.	-	hailstorm, May 26; $125 million in damage
1988	Edmonton, Alta.	-	hailstorm, June 7; $48 million in damage
1988	Calgary, Alta.	-	hailstorm, August 16; $30 million in damage
1989	Southern Ontario	-	severe rainstorm; flooding in Kent, Essex and Leamington counties; $15 million in damage
1989	Dryden, Ont.	24	Air Ontario flight crashed in snowstorm; ice on wings
1989	Gulf of St. Lawrence	39	vessels *Johanna B* and *Capitaine Torres* sank
1989	Nova Scotia	1	Hurricane Gabrielle battered coast; swells of 6 to 9 metres and winds gusting up to 150 km/h
1990	Calgary, Alta.	-	hailstorm, July 9; insured loss reported at $16 million
1990	Nova Scotia and Prince Edward Island	6	Hurricane Bertha; P.E.I.'s corn and tobacco crops damaged; victims were crew on cargo ship
1991	Red Deer, Alta.	-	hailstorm over area of 30 km^2, July 3; insured losses estimated at $50 million
1991	Southern New Brunswick	2	Hurricane Bob, August 19; winds to 100 km/h
1991	Calgary, Alta.		hailstorm over area of 130 km^2, September 7; more than $400 million in damage
1991	Vernon, B.C.	-	windstorm, October 16; $4 million in damage
1991	Maritimes	-	Hurricane Grace and unnamed hurricane over North Atlantic; damage reported at $10 million
1991	Ontario	-	windstorm, November 30; $5 million in damage
1991	Newfoundland	33	freighter *Protektor* sank 400 kilometres off east coast
1991	Newfoundland	-	severe winter storm, December 25; some evacuations in Placentia Bay
1992	Calgary, Alta.	-	hailstorm, July 31; losses estimated at $22 million
1992	Alberta	-	hailstorm, August 28; $5 million in damage
1992	Alberta	-	hailstorm; September 1; $7 million in damage

Table 3.4.4
Major Storms, 1583-1998 (continued)

Year	Location	Number of deaths	Description
1992	Newfoundland	-	violent storm, October 6; several buildings damaged and utilities disrupted; damage reported at $9 million
1992	Ontario	-	windstorm, November 12-13; $26 million in damage
1992	Quebec	-	windstorm, November 13; $8 million in damage
1993	Alberta	-	July hailstorm; insured loss reported at $8 million
1993	Yarmouth, N.S.	33	vessel *Gold Bond Conveyor* sank off coast
1993	Ontario and Quebec	-	severe winter weather, November 1993 through March 1994; more than $50 million in damage
1994	Montréal, Que.	6	severe snowstorm; major highway accidents near Montréal, with pile-ups of up to 100 cars
1994	Salmon Arm, B.C.	-	August hailstorm; insured loss of $15 million reported
1994	Prairies	-	several hailstorms; insured losses of $200 million in crop damage
1994	Newfoundland	29	vessel *Salvador Allende* sank
1995	Prairies	-	several hailstorms; $200 million in crop damage and $50 million in residence and vehicle damage
1996	Calgary, Alta. and Winnipeg, Man.	-	hailstorm, July 16; insured cost reached $150 million
1997	Southern British Columbia	-	floods from severe thunderstorms, March 18-24; residential, farm, business and government buildings damaged
1998	Newfoundland	21	freighter *Flare* sank
1998	Eastern Ontario and southern Quebec	28	up to 100 millimetres of freezing rain, Jan 4-10; massive power outages; 945 injured; $3 billion in damage

Notes:
The main criterion for inclusion of storms in this table is significant impact on people. Significant events are not included if they caused little damage or occurred in isolated areas.
Unless otherwise specified, value of damage is expressed in dollars of the year of the disaster.
Sources:
Emergency Preparedness Canada, Department of National Defence, *EPC Electronic Disaster Database*, <http://www.epc-pcc.gc.ca/research/epcdatab.html>, (accessed December 9, 1999).
Jones, Robert L., *Canadian Disasters - An Historical Survey*, <http://www.ott.igs.net/~jonesb/DisasterPaper/disasterpaper.html>, (accessed December 9, 1999).

Map 3.4.6
Tornadoes



Source:
Natural Resources Canada, Geomatics Canada, *Natural Hazards: Tornadoes, Windstorms and Hurricanes*, <http://cgdi.gc.ca/ccatlas/hazardnet/e_winddanger/wind5.htm>, (accessed December 22, 1998).

Text Box 3.4.6
Edmonton Tornado, 1987

On July 31, 1987 thunderstorms developed over the Rocky Mountain foothills and moved toward the city of Edmonton. Simultaneously, a line of thunderstorms was intensifying southwest of the city. From these storms developed a tornado that touched down just south of Edmonton at 3:01 p.m. and ripped through the eastern subdivisions of the city during the next hour. Winds of up to 400 km/h destroyed an area 40 kilometres long and 1 kilometre wide. The tornado wreaked destruction throughout the city with hailstones—reportedly as large as softballs—and 40 to 50 millimetres of rain. The death toll reached 27, with another 300 injured. Hundreds were left homeless and property damage was reported at over $150 million.

Sources:
Environment Canada, 1990, *The Climates of Canada*, Ottawa.
Natural Resources Canada, Geomatics Canada, *Natural Hazards: Tornadoes*, <http://cgdi.gc.ca/ccatlas/hazardnet/e_winddanger/wind4.htm>, (accessed December 22, 1998).

Table 3.4.5
Major Tornadoes, 1879-1999

Year	Location	Number of deaths	Description
1879	Bouctouche, N.B.	7	August 6; 25 families homeless; minor damage
1888	Valleyfield, Que.	9	August 16; widespread damage from Valleyfield to St. Zotique
1912	Regina, Sask.	29	June 30; hundreds injured; $4 million in damage; more than 400 buildings destroyed
1922	Portage la Prairie, Man.	5	June 22; many injured; $2 million in damage
1944	Windsor, Ont.	16	June 17; many injured; extensive damage
1946	Lake St. Clair, Ont.	17	June 17; widespread damage from Windsor to Tecumseh; hundreds injured
1953	Sarnia, Ont.	7	May 21; extensive damage; 40 injured and 500 left homeless
1955	Vita, Man.	-	June 19; hundreds injured
1970	Sudbury, Ont.	6	August 20; extensive property damage of $10 million or more; 200 injured and 750 left homeless
1974	Windsor, Ont.	9	April 3; 30 injured; damage estimated at $500 000
1975	Saint-Bonaventure, Que.	-	July 25; $2.5-3 million in damage; 40 injured and 300 left homeless
1979	Woodstock, Ont.	2	August 7; three tornadoes; extensive damage estimated at $7 million
1980	Brampton, Ont.	-	May 31; extensive property damage
1982	Montréal (Ste-Rose), Que.	6	June 14; extensive property damage; 26 injured
1984	West Quebec	1	July 15; 38 injured; minor damage
1984	Toronto, Ont.	-	August 14; extensive damage
1984	London, Ont.	-	September 2; 30 injuries; damage estimated at $65 million
1985	Hopeville, Ont. to Barrie, Ont.	12	May 31; $117 million in damage; 500 injured; 300 homes destroyed and 800 left homeless
1987	Edmonton, Alta.	27	July 31; $150 million in damage; 300 injured and 1 700 left homeless
1988	Medicine Hat, Alta.	-	June 7; $50 million in damage
1990	Frome, Ont.	-	August 28; crops damaged and several buildings destroyed; minor injuries
1991	Maskinongé, Que.	-	August 27; 60% of all village buildings damaged; 15 injured; damage estimated at $13 million
1991	Sarnia, Ont.	-	March 27; estimated at $25 million in damage
1994	Aylmer, Que.	-	August 4; extensive damage; minor injuries
1996	Arthur, Ont. and Williamsford, Ont.	-	April 20; two tornadoes; several million dollars in damage; minor injuries
1998	Norwich, Ont.	-	June 2; extensive damage
1999	Hull, Que.	-	May 8; six injured; $3 million in damage

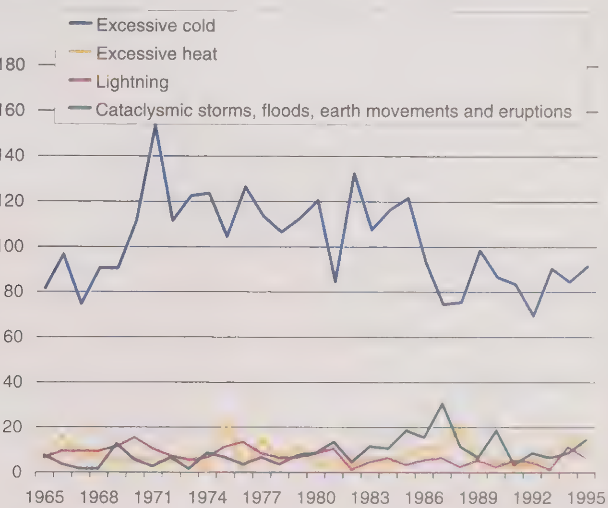
Notes:
The main criterion for inclusion of tornadoes in this table is significant impact on people. Some significant events are not included if they caused little damage or occurred in isolated areas.
Unless otherwise specified, value of damage is expressed in dollars of the year of the disaster.
Sources:
Emergency Preparedness Canada, Department of National Defence, *EPC Electronic Disaster Database*, <http://www.epc-pcc.gc.ca/research/epcdatab.html>, (accessed December 9, 1999).
Jones, Robert L., *Canadian Disasters - An Historical Survey*, <http://www.ott.igs.net/~jonesb/Disasterpaper/disasterpaper.html>, (accessed December 9, 1999).

Text Box 3.4.7
Killer Canadian Weather

According to mortality figures compiled by Statistics Canada, exposure to extreme cold claims more lives in Canada than heat waves, lightning, storms, floods, tornadoes and earthquakes combined. From 1965 to 1995, a total of 3 135 deaths were attributed to 'excessive cold.' Compared with other natural and environmental causes of death, excessive cold claims 101 people per year on average, while heat, lightning and cataclysmic events claim only 7, 6 and 10 per year, respectively.

Sources:
Statistics Canada, 1993-1997, *Causes of Death, 1991-1995*, Catalogue No. 84-208-XPB, Ottawa.
Statistics Canada, 1989-1992, *Health Reports Supplement, Causes of Death, 1987–1990*, Catalogue No. 84-208, Ottawa.
Statistics Canada, 1984-1988, *Causes of Death, Vital Statistics, Volume IV, 1982-1986*, Catalogue No. 84-203, Ottawa.
Statistics Canada, 1967-1982, *Causes of Death, Canada, Provinces by sex and Canada by sex and age, 1965-1981*, Catalogue No. 84-203, Ottawa.

Figure 3.4.1
Causes of Death: Accidents Due to Natural and Environmental Factors, 1965-1995



4 Driving Forces

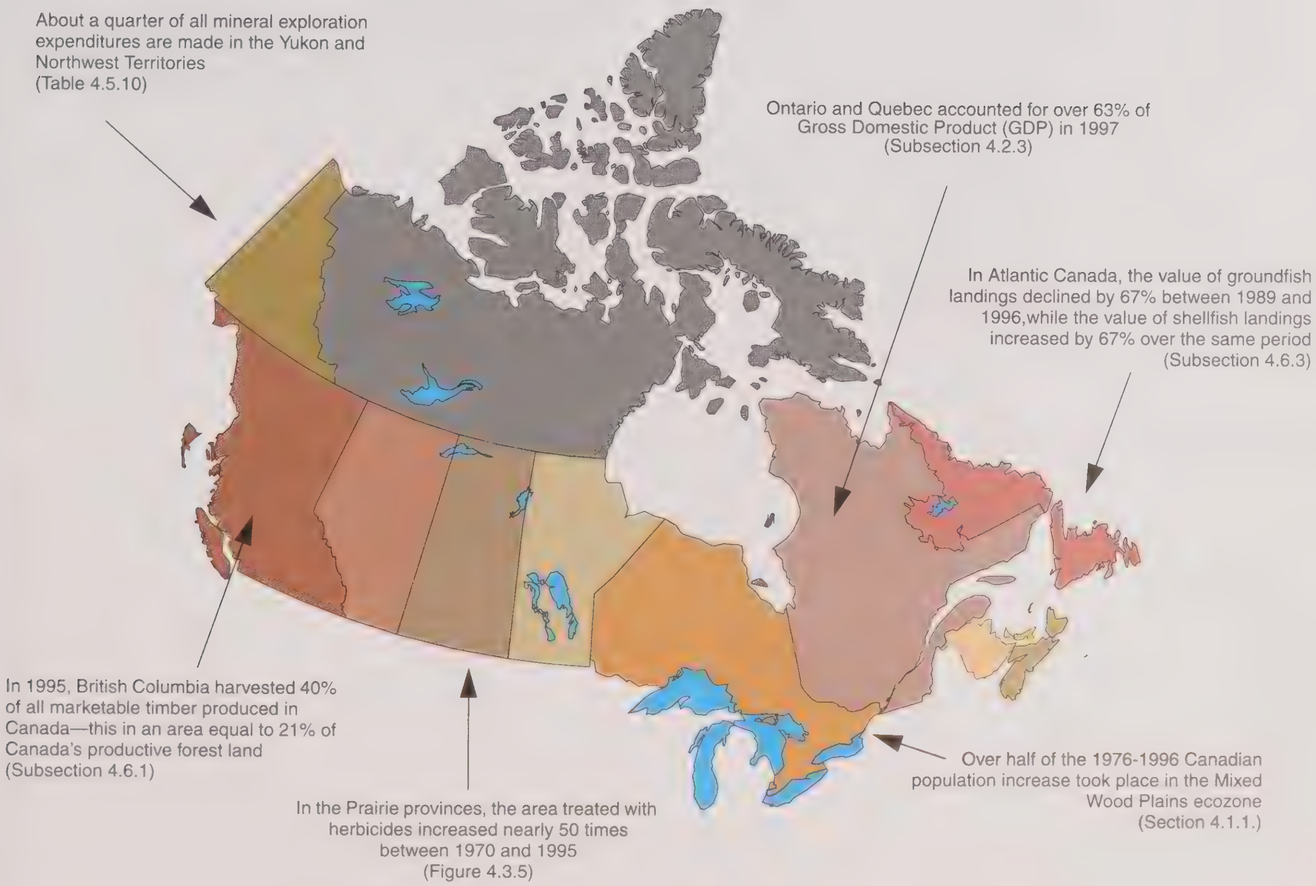
Introduction

It has long been recognized that population growth, economic expansion and technological development account for the growing pressure on the earth's physical environment. These human activities have a strong impact on landscape, biological diversity and climatic cycles.

In this chapter we examine the evolution of the driving forces that bring about environmental change—population, economy, and science and technology. These driving forces include developments—such as mechanization and urbanization—that shape the agriculture, fisheries, forest, mineral and transport industries, all of which are heavily dependent on natural resources.

Humans have become powerful agents of environmental change.

Map 4.1
Driving Forces Highlights



4.1 Population

Population growth, distribution and density are major factors in determining the impacts that human activities have on the environment. In 1950, world population was estimated to be 2.5 billion. By 1999, that number was approaching 6 billion people, half of whom lived in six countries (China, India, the United States, Indonesia, Brazil and Russia).[1] We are growing at a rate of just under three persons per second, or over 80 million people per year.[2] It is, therefore, no surprise that population and environment issues are becoming increasingly important.

4.1.1 Population distribution and density

Canada's population has expanded considerably since 1901, when there were 5.4 million Canadians (Table 4.1.1). By 1996, the population had grown more than five-fold, reaching nearly 30 million people. However, growth rates have not been consistent over time. Two historical periods were characterized by high annual population growth rates. The first was from 1901 to 1911, when massive immigration resulted in annual growth rates of up to 3%. European immigrants were arriving to work in eastern Canada's manufacturing industries or to benefit from abundant agricultural land available in western Canada. High growth continued until the beginning of the First World War in 1914. The second period of high growth followed the end of the Second World War and is generally referred to as the 'baby boom.' In contrast to these two periods of population growth, two periods of slow economic activity (1891 to 1901 and 1931 to 1941) coincided with a slump in population growth rates. Since 1956, when the annual rate was 2.8%, growth rates have been decreasing, fluctuating between 1% and 1.8% since 1970.[3,4]

1. United States Bureau of Census, 1996, *World Population at a Glance: 1996 and Beyond*, USBC Report IB/96-3, Washington.
2. Brown, L.R. and H. Kane, 1994, *Full House: Reassessing the Earth's Population Carrying Capacity*, W.W. Norton and Company, New York.

Text Box 4.1.1
How Many Canadians, Exactly?

A close examination of the various population figures in *Human Activity and the Environment 2000* reveals that they are not all the same. This book uses two different population data sources: census counts and population estimates. The census counts are used whenever the level of geography is too detailed to permit the use of estimates. The estimates are census counts that are adjusted for net undercoverage and non-permanent residents, and are considered to be our best population figures.

Population distribution

In 1901, Ontario was Canada's most populous province, followed by Quebec. This ranking is still valid today, although Quebec's share of total Canadian population has been decreasing constantly since then. Elsewhere in Canada, the demographic weight has been inverted, east to west. The Atlantic provinces accounted for 16.6% of the total population in 1901, but only 8.0% in 1996. In contrast, the western provinces, which accounted for only 11.4% of the total Canadian population in 1901, reported 29.7% of the population in 1996.

The westward shift of Canada's population throughout the 20th century is shown in Figure 4.1.1. The Canadian population grew at its highest rate—76%—during the first

3. Statistics Canada, 1980, *Perspectives Canada III*, Catalogue No. 11-511E, Ottawa.
4. Owram, D.,1996, *Born at the Right Time: A History of the Baby Boom Generation*, University of Toronto Press, Toronto.

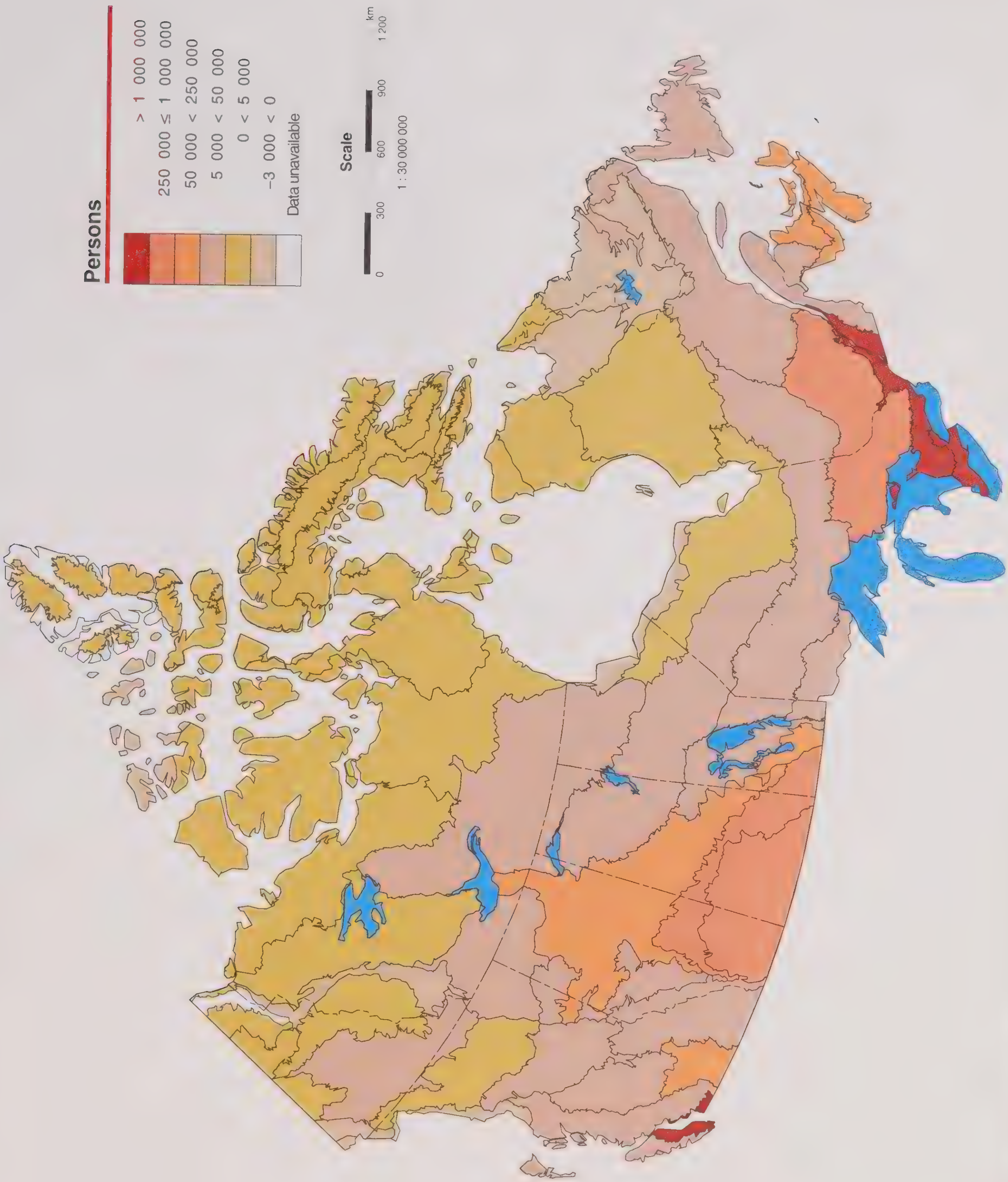
Table 4.1.1
Total Population by Province and Territory, 1901, 1951 and 1996

Province/Territory	Total population 1901	Total population 1951	Total population 1996	Change 1901-1951	Change 1951-1996
	thousands			percent	
Newfoundland	...	361.4	560.6	...	55
Prince Edward Island	103.3	98.4	136.2	-5	38
Nova Scotia	459.6	642.6	931.2	40	45
New Brunswick	331.1	515.7	753.0	56	46
Quebec	1 648.9	4 055.7	7 274.0	146	79
Ontario	2 182.9	4 597.5	11 100.9	111	141
Manitoba	255.2	776.5	1 134.3	204	46
Saskatchewan	91.3	831.7	1 019.5	811	23
Alberta	73.0	939.5	2 780.6	1 187	196
British Columbia	178.7	1 165.2	3 882.0	552	233
Yukon Territory	27.2	9.1	31.9	-67	251
Northwest Territories	20.1	16.0	67.6	-20	322
Canada	**5 371.3**	**14 009.4**	**29 671.9**	**161**	**112**

Sources:
Statistics Canada, 1983, *Historical Statistics of Canada*, Second Edition, F.H. Leacy (ed.), Catalogue No. 11-516E, Ottawa.
Statistics Canada, CANSIM, matrix 1.

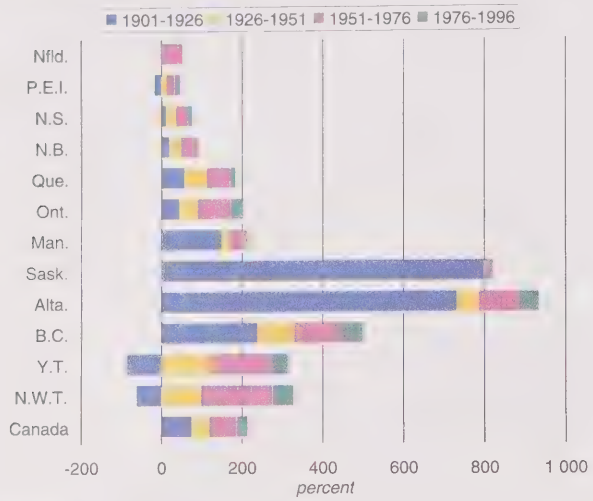
Map 4.1.1

Population Change by Ecoprovince, 1971-1996



Sources:
Statistics Canada, Environment Accounts and Statistics Division, and Census of Population.

Figure 4.1.1
Population Growth Rate by Province and Territory, 1901-1996



Sources:
Statistics Canada, 1983, *Historical Statistics of Canada*, Second Edition, F.H. Leacy (ed.), Catalogue No. 11-516E, Ottawa.
Statistics Canada, CANSIM, matrices 1 and 599.

quarter of the 20th century. The largest growth rates at the time belonged to the western provinces. The national growth rate was lowest in the final quarter of the 20th century. Nonetheless, this has still meant an overall population increase of more than 6.2 million people.

The distribution of population by ecozone[1] illustrates the unevenness of Canada's population distribution (Table 4.1.2). Population growth between 1976 and 1996 occurred primarily in three ecozones. The most significant growth took place in the Mixed Wood Plains, which covers an area that roughly corresponds to the Quebec–Windsor corridor. This ecozone experienced the largest population change, accounting for 54% of the national increase. The two other ecozones where moderate growth occurred were the Pacific Maritime and Prairie ecozones. Within the Pacific Maritime ecozone, growth has mainly occurred in a single ecoprovince, the Georgian Depression (Table 4.1.3). Map 4.1.1 further emphasizes the fact that population change has occurred mainly in the ecoprovinces of the Mixed Wood Plains ecozone.

1. See section 3.1–**Environmental geographies** for more information on the ecozone classification.

Table 4.1.2
Population by Provincial and Territorial Ecozone, 1976, 1986 and 1996

		Population					Density				
Provincial/Territorial ecozone	Area	1976	1986	1996	Change 1976-1996	Change 1986-1996	1976	1986	1996	Change 1976-1996	Change 1986-1996
	km²	persons					persons per km²			percent	
Newfoundland											
Boreal Shield	161 859	553 911	563 809	547 624	-6 287	-16 185	3.422	3.483	3.383	-1.1	-2.9
Taiga Shield	219 766	3 814	4 540	4 168	354	-372	0.017	0.021	0.019	9.3	-8.2
Arctic Cordillera	19 382	-	-	-	-	-	-	-	-	-	-
Total	**401 007**	**557 725**	**568 349**	**551 792**	**-5 933**	**-16 557**	**1.391**	**1.417**	**1.376**	**-1.1**	**-2.9**
Prince Edward Island											
Atlantic Maritime	5 712	118 229	126 646	134 557	16 328	7 911	20.697	22.171	23.556	13.8	6.2
Total	**5 712**	**118 229**	**126 646**	**134 557**	**16 328**	**7 911**	**20.697**	**22.171**	**23.556**	**13.8**	**6.2**
Nova Scotia											
Atlantic Maritime	56 352	828 571	873 176	909 282	80 711	36 106	14.703	15.495	16.136	9.7	4.1
Total	**56 352**	**828 571**	**873 176**	**909 282**	**80 711**	**36 106**	**14.703**	**15.495**	**16.136**	**9.7**	**4.1**
New Brunswick											
Atlantic Maritime	73 318	677 249	709 442	738 133	60 884	28 691	9.237	9.676	10.068	9.0	4.0
Total	**73 318**	**677 249**	**709 442**	**738 133**	**60 884**	**28 691**	**9.237**	**9.676**	**10.068**	**9.0**	**4.0**
Quebec											
Boreal Shield	642 880	1 090 178	1 154 683	1 285 777	195 599	131 094	1.696	1.796	2.000	17.9	11.3
Taiga Shield	530 006	10 243	7 302	10 193	-50	2 891	0.019	0.014	0.019	-0.5	39.6
Atlantic Maritime	67 237	731 031	760 011	767 089	36 058	7 078	10.873	11.304	11.409	4.9	0.9
Arctic Cordillera	13 497	285	-	-	-285	-	0.021	-	-	-100.0	-
Northern Arctic	36 734	990	1 208	1 614	624	406	0.027	0.033	0.044	63.0	33.6
Southern Arctic	154 081	863	2 586	3 642	2 779	1 056	0.006	0.017	0.024	322.0	40.8
Mixed Wood Plains	28 357	4 399 784	4 605 131	5 068 405	668 621	463 274	155.155	162.396	178.733	15.2	10.1
Hudson Plains	37 377	1 071	1 540	2 075	1 004	535	0.029	0.041	0.056	93.7	34.7
Total	**1 510 169**	**6 234 445**	**6 532 461**	**7 138 795**	**904 350**	**606 334**	**4.128**	**4.326**	**4.727**	**14.5**	**9.3**
Ontario											
Boreal Shield	640 637	951 620	926 174	973 823	22 203	47 649	1.485	1.446	1.520	2.3	5.1
Mixed Wood Plains	85 613	7 307 855	8 173 130	9 772 006	2 464 151	1 598 876	85.359	95.466	114.141	33.7	19.6
Hudson Bay Plains	263 078	4 990	2 390	7 744	2 754	5 354	0.019	0.009	0.029	55.2	224.0
Total	**989 328**	**8 264 465**	**9 101 694**	**10 753 573**	**2 489 108**	**1 651 879**	**8.354**	**9.200**	**10.870**	**30.1**	**18.1**

Table 4.1.2
Population by Provincial and Territorial Ecozone, 1976, 1986 and 1996 (continued)

Provincial/Territorial ecozone	Area	Population					Density				
		1976	1986	1996	Change 1976-1996	Change 1986-1996	1976	1986	1996	Change 1976-1996	Change 1986-1996
	km^2	persons					persons per km^2			percent	
Manitoba											
Boreal Shield	250 040	72 343	67 583	72 175	-168	4 592	0.289	0.270	0.289	-0.2	6.8
Taiga Shield	130 373	572	1 217	1 445	873	228	0.004	0.009	0.011	152.6	18.7
Southern Arctic	1 492	-	-	-	-	-	-	-	-	-	-
Hudson Plains	70 246	3 268	2 428	1 992	-1 276	-436	0.047	0.035	0.028	-39.0	-18.0
Boreal Plains	90 540	101 863	104 960	116 087	14 224	11 127	1.125	1.159	1.282	14.0	10.6
Prairie	67 072	843 460	886 828	922 199	78 739	35 371	12.575	13.222	13.749	9.3	4.0
Total	**609 763**	**1 021 506**	**1 063 016**	**1 113 898**	**92 392**	**50 882**	**1.675**	**1.743**	**1.827**	**9.0**	**4.8**
Saskatchewan											
Boreal Shield	176 185	8 990	12 993	16 035	7 045	3 042	0.051	0.074	0.091	78.4	23.4
Taiga Shield	46 657	2 745	1 214	1 254	-1 491	40	0.059	0.026	0.027	-54.3	3.3
Boreal Plains	177 644	156 272	162 431	159 468	3 196	-2 963	0.880	0.914	0.898	2.0	-1.8
Prairie	240 978	753 316	832 975	813 480	60 164	-19 495	3.126	3.457	3.376	8.0	-2.3
Total	**641 464**	**921 323**	**1 009 613**	**990 237**	**68 914**	**-19 376**	**1.436**	**1.574**	**1.544**	**7.5**	**-1.9**
Alberta											
Boreal Shield	4 540	-	-	-	-	-	-	-	.	.	.
Taiga Shield	8 921	-	-	-	-	-	-	-	-	.	.
Boreal Plains	381 674	284 698	373 651	413 332	128 634	39 681	0.746	0.979	1.083	45.2	10.6
Prairie	156 021	1 525 752	1 962 123	2 243 843	718 091	281 720	9.779	12.576	14.382	47.1	14.4
Taiga Plains	62 518	1 802	2 048	3 153	1 351	1 105	0.029	0.033	0.050	75.0	54.0
Montane Cordillera	47 394	25 785	28 003	36 498	10 713	8 495	0.544	0.591	0.770	41.5	30.3
Total	**661 067**	**1 838 037**	**2 365 825**	**2 696 826**	**858 789**	**331 001**	**2.780**	**3.579**	**4.080**	**46.7**	**14.0**
British Columbia											
Boreal Plains	39 355	38 539	45 813	52 759	14 220	6 946	0.979	1.164	1.341	36.9	15.2
Taiga Plains	67 593	3 691	5 026	5 798	2 107	772	0.055	0.074	0.086	57.1	15.4
Montane Cordillera	442 840	595 381	670 740	815 158	219 777	144 418	1.344	1.515	1.841	36.9	21.5
Pacific Maritime	208 805	1 825 947	2 158 515	2 848 289	1 022 342	689 774	8.745	10.337	13.641	56.0	32.0
Boreal Cordillera	192 095	3 050	3 273	2 496	-554	-777	0.016	0.017	0.013	-18.2	-23.7
Total	**950 688**	**2 466 608**	**2 883 367**	**3 724 500**	**1 257 892**	**841 133**	**2.595**	**3.033**	**3.918**	**51.0**	**29.2**
Yukon Territory											
Southern Arctic	4 563	-	-	-	-	-	-	-	-	.	.
Taiga Plains	18 357	-	-	-	-	-	-	-	-	.	.
Pacific Maritime	4 196	-	-	-	-	-	-	-	-	-	-
Boreal Cordillera	273 711	21 612	23 210	30 408	8 796	7 198	0.079	0.085	0.111	40.7	31.0
Taiga Cordillera	182 824	224	294	358	134	64	0.001	0.002	0.002	59.8	21.8
Total	**483 652**	**21 836**	**23 504**	**30 766**	**8 930**	**7 262**	**0.045**	**0.049**	**0.064**	**40.9**	**30.9**
Northwest Territories											
Taiga Shield	432 000	9 889	13 531	19 829	9 940	6 298	0.023	0.031	0.046	100.5	46.5
Arctic Cordillera	211 705	814	925	1 196	382	271	0.004	0.004	0.006	46.9	29.3
Northern Arctic	1 493 093	9 646	12 973	17 267	7 621	4 294	0.006	0.009	0.012	79.0	33.1
Southern Arctic	691 537	5 167	6 768	8 087	2 920	1 319	0.007	0.010	0.012	56.5	19.5
Hudson Plains	3 570	-	-	-	-	-	-	-	-	.	.
Boreal Plains	15 506	4 704	4 479	2 988	-1 716	-1 491	-	-	-	.	.
Taiga Plains	462 074	12 389	13 324	15 035	2 646	1 711	0.027	0.029	0.033	21.4	12.8
Boreal Cordillera	4 670	-	-	-	-	-	-	-	-	.	.
Taiga Cordillera	84 459	-	238	-	-	-238	-	0.003	-	-	-100.0
Total	**3 398 613**	**42 609**	**52 238**	**64 402**	**21 793**	**12 164**	**0.013**	**0.015**	**0.019**	**51.1**	**23.3**
Canada total	**9 781 133**	**22 992 603**	**25 309 331**	**28 846 761**	**5 854 158**	**3 537 430**	**2.351**	**2.588**	**2.949**	**25.5**	**14.0**

Table 4.1.2
Population by Provincial and Territorial Ecozone, 1976, 1986 and 1996 (continued)

		Population					Density				
Provincial/Territorial ecozone	Area	1976	1986	1996	Change 1976-1996	Change 1986-1996	1976	1986	1996	Change 1976-1996	Change 1986-1996
	km²	persons					persons per km²			percent	
Ecozone											
Boreal Shield	1 876 142	2 677 042	2 725 242	2 895 437	218 395	170 195	1.427	1.453	1.543	8.2	6.2
Taiga Shield	1 367 722	27 249	27 804	36 889	9 640	9 085	0.020	0.020	0.027	35.4	32.7
Atlantic Maritime	202 619	2 355 080	2 469 275	2 549 061	193 981	79 786	11.623	12.187	12.581	8.2	3.2
Arctic Cordillera	244 584	1 099	925	1 196	97	271	0.004	0.004	0.005	8.8	29.3
Northern Arctic	1 529 827	10 636	14 181	18 881	8 245	4 700	0.007	0.009	0.012	77.5	33.1
Southern Arctic	851 673	6 034	9 354	11 729	5 695	2 375	0.007	0.011	0.014	94.4	25.4
Mixed Wood Plains	113 971	11 707 639	12 778 261	14 840 411	3 132 772	2 062 150	102.725	112.119	130.212	26.8	16.1
Hudson Plains	374 270	9 343	6 358	11 811	2 468	5 453	0.025	0.017	0.032	26.4	85.8
Boreal Plains	704 719	586 076	691 334	744 631	158 555	53 297	0.832	0.981	1.057	27.1	7.7
Prairie	464 070	3 122 528	3 681 926	3 979 522	856 994	297 596	6.729	7.934	8.575	27.4	8.1
Taiga Plains	610 542	17 882	20 398	23 986	6 104	3 588	0.029	0.033	0.039	34.1	17.6
Montane Cordillera	490 234	621 166	698 743	851 656	230 490	152 913	1.267	1.425	1.737	37.1	21.9
Pacific Maritime	213 000	1 825 947	2 158 515	2 848 289	1 022 342	689 774	8.573	10.134	13.372	56.0	32.0
Boreal Cordillera	470 476	24 658	26 483	32 904	8 246	6 421	0.052	0.056	0.070	33.4	24.2
Taiga Cordillera	267 284	224	532	358	134	-174	0.001	0.002	0.001	59.8	-32.7
Canada total	**9 781 133**	**22 992 603**	**25 309 331**	**28 846 761**	**5 854 158**	**3 537 430**	**2.351**	**2.588**	**2.949**	**25.5**	**14.0**

Notes:
The area figures do not include a number of large freshwater bodies. The total area of Canada including these water bodies is 9 970 610 km².
Ecozone boundaries are the 1996 set produced by the Ecological Stratification Working Group and in some instances differ from previously released compilations.
The population figures presented here are not adjusted for net undercoverage and non-permanent residents.
Sources:
Statistics Canada, Environment Accounts and Statistics Division, and Census of Population.
Ecological Stratification Working Group, 1996, *A National Ecological Framework for Canada*, Agriculture and Agri-Food Canada, Research Branch, Centre for Land and Biological Resources Research and Environment Canada, State of the Environment Directorate, Ecozone Analysis Branch, Ottawa.

Table 4.1.3
Population by Ecozone and Ecoprovince,[1] 1971 and 1996

		Population			Density	
Ecozone/Ecoprovince	Area	1971	1996	Change 1971-1996	1971	1996
	km²	persons			persons per 100 km²	
Boreal Shield						
Western Boreal Shield	515 342	59 811	74 020	14 209	11.61	14.36
Mid-Boreal Shield	498 351	290 335	300 955	10 620	58.26	60.39
Eastern Boreal Shield	357 162	385 669	411 972	26 303	107.98	115.35
Newfoundland	111 280	493 938	522 602	28 664	443.87	469.63
Lake of the Woods	74 179	195 276	207 565	12 289	263.25	279.82
Southern Boreal Shield	319 742	1 117 870	1 378 647	260 777	349.62	431.18
Total	**1 876 056**	**2 542 899**	**2 895 761**	**352 862**	**135.54**	**154.35**
Taiga Shield						
Western Taiga Shield	617 153	11 102	22 036	10 934	1.80	3.57
Eastern Taiga Shield	394 282	3 285	6 416	3 131	0.83	1.63
Labrador Uplands	240 989	7 045	4 659	-2 386	2.92	1.93
Whale River Lowland	114 915	4 733	3 777	-956	4.12	3.29
Total	**1 367 339**	**26 165**	**36 888**	**10 723**	**1.91**	**2.70**
Atlantic Maritime						
Appalachian-Acadian Highlands	94 980	812 377	852 078	39 701	855.32	897.11
Northumberland Lowlands	35 361	502 937	602 791	99 854	1 422.31	1 704.70
Fundy Uplands	72 207	953 521	1 094 192	140 671	1 320.53	1 515.35
Total	**202 548**	**2 268 835**	**2 549 061**	**280 226**	**1 120.15**	**1 258.50**
Arctic Cordillera						
Northern Arctic Cordillera	114 954	-	-	-	-	-
Southern Arctic Cordillera	129 538	843	1 196	353	0.65	0.92
Total	**244 492**	**843**	**1 196**	**353**	**0.34**	**0.49**
Northern Arctic						
Sverdrup Islands	65 078	22	-	-22	0.03	-
Ellesmere Basin	135 527	..	..	..	..	..
Victoria Lowlands	429 912	1 570	3 810	2 240	0.37	0.89
Parry Channel Plateaux	135 666	785	2 250	1 465	0.58	1.66
Boothia-Foxe Shield	551 288	6 094	10 590	4 496	1.11	1.92
Baffin Uplands	131 359	-	18	18	-	0.01
Foxe-Boothia Lowlands	80 948	1 041	2 213	1 172	1.29	2.73
Total	**1 529 778**	**9 512**	**18 881**	**9 369**	**0.62**	**1.23**

Table 4.1.3
Population by Ecozone and Ecoprovince,[1] 1971 and 1996 (continued)

Ecozone/Ecoprovince	Area	Population 1971	Population 1996	Population Change 1971-1996	Density 1971	Density 1996
	km^2	persons			persons per 100 km^2	
Southern Arctic						
Amundsen Lowlands	310 894	1 482	2 481	999	0.48	0.80
Keewatin Lowlands	382 324	1 993	4 975	2 982	0.52	1.30
Ungava-Belcher	157 574	786	4 273	3 487	0.50	2.71
Total	**850 792**	**4 261**	**11 729**	**7 468**	**0.50**	**1.38**
Mixed Wood Plains						
Great Lakes-St. Lawrence Lowlands	89 582	6 487 867	8 481 732	1 993 865	7 242.34	9 468.07
Huron-Erie Plains	24 465	4 541 655	6 357 815	1 816 160	18 563.66	25 987.08
Total	**114 048**	**11 029 522**	**14 839 547**	**3 810 025**	**9 670.97**	**13 011.70**
Hudson Plains						
Hudson Bay Coastal Plains	63 045	3 153	1 690	-1 463	5.00	2.68
Hudson-James Lowlands	311 225	6 893	10 121	3 228	2.21	3.25
Total	**374 270**	**10 046**	**11 811**	**1 765**	**2.68**	**3.16**
Boreal Plains						
Boreal Foothills	120 996	39 466	68 656	29 190	32.62	56.74
Central Boreal Plains	486 281	432 332	566 561	134 229	88.91	116.51
Eastern Boreal Plains	97 426	87 745	109 955	22 210	90.06	112.86
Total	**704 702**	**559 543**	**745 172**	**185 629**	**79.40**	**105.74**
Prairie						
Eastern Prairies	30 027	676 951	792 347	115 396	2 254.50	2 638.81
Parkland Prairies	177 690	1 227 324	1 760 229	532 905	690.71	990.62
Central Grassland	256 369	1 013 200	1 426 946	413 746	395.21	556.60
Total	**464 085**	**2 917 475**	**3 979 522**	**1 062 047**	**628.65**	**857.50**
Taiga Plains						
Mackenzie Foothills	86 483	807	-	-807	0.93	-
Great Bear Lowlands	302 879	5 140	8 212	3 072	1.70	2.71
Hay-Slave Lowlands	222 664	9 459	15 774	6 315	4.25	7.08
Total	**612 026**	**15 406**	**23 986**	**8 580**	**2.52**	**3.92**
Montane Cordillera						
Northern Montane Cordillera	141 283	80 502	130 113	49 611	56.98	92.09
Central Montane Cordillera	106 023	48 230	77 717	29 487	45.49	73.30
Southern Montane Cordillera	59 338	222 223	442 179	219 956	374.50	745.19
Columbia Montane Cordillera	183 786	158 193	201 647	43 454	86.07	109.72
Total	**490 430**	**509 148**	**851 656**	**342 508**	**103.82**	**173.66**
Pacific Maritime						
Georgia Depression	19 565	1 551 272	2 712 475	1 161 203	7 928.72	13 863.75
Southern Coastal Mountains	160 848	100 460	134 636	34 176	62.46	83.70
Northern Coastal Mountains	32 393	2 095	1 178	-917	6.47	3.64
Total	**212 807**	**1 653 827**	**2 848 289**	**1 194 462**	**777.15**	**1 338.44**
Boreal Cordillera						
Wrangel Mountains	24 472	376	34	-342	1.54	0.14
Northern Boreal Cordillera	239 102	17 005	27 967	10 962	7.11	11.70
Southern Boreal Cordillera	168 192	2 405	2 769	364	1.43	1.65
Western Boreal Cordillera	38 704	827	2 134	1 307	2.14	5.51
Total	**470 470**	**20 613**	**32 904**	**12 291**	**4.38**	**6.99**
Taiga Cordillera						
Northern Yukon Mountains	26 848	..	..	..	..	..
Old Crow-Eagle Plains	41 387	216	278	62	0.52	0.67
Ogilvie Mountains	39 515	-	32	32	-	0.08
Mackenzie-Selwyn Mountains	159 540	-	48	48	-	0.03
Total	**267 291**	**216**	**358**	**142**	**0.08**	**0.13**
Canada total	**9 781 133**	**21 568 311**	**28 846 761**	**7 278 450**	**220.51**	**294.92**

Notes:
The area figures do not include a number of large freshwater bodies. The total area of Canada including these water bodies is 9 970 610 km^2.
The population figures presented here are not adjusted for net undercoverage and non-permanent residents.
1. Ecoprovince boundaries were taken from an unpublished digital map prepared by Agriculture and Agri-Food Canada, Research Branch, Canadian Soil Information System (CanSIS), Ottawa, in co-operation with Environment Canada, State of the Environment Directorate, Ecozone Analysis Branch, Ottawa/Hull, 1997.
Sources:
Statistics Canada, Environment Accounts and Statistics Division, and Census of Population.
Ecological Stratification Working Group, 1996, *A National Ecological Framework for Canada*, Agriculture and Agri-Food Canada, Research Branch, Centre for Land and Biological Resources Research and Environment Canada, State of the Environment Directorate, Ecozone Analysis Branch, Ottawa.

Table 4.1.4
Population Density, 1901, 1951 and 1996

Province/Territory	1901	1951	1996
	persons per km²		
Newfoundland	...	0.942	1.382
Prince Edward Island	18.255	17.402	24.061
Nova Scotia	8.556	11.961	16.782
New Brunswick	4.614	7.247	10.253
Quebec	1.216	2.757	4.721
Ontario	2.320	4.888	10.388
Manitoba	0.448	1.363	1.745
Saskatchewan	0.147	1.351	1.563
Alberta	0.112	1.459	4.206
British Columbia	0.193	1.251	4.096
Yukon Territory	0.050	0.015	0.066
Northwest Territories	0.008	0.004	0.020
Canada	**0.598**	**1.498**	**2.976**

Note:
Density in years previous to 1941 is based on 1941 areas.
Density is calculated using population estimates.
Sources:
Statistics Canada, 1983, *Historical Statistics of Canada*, Second Edition, F.H. Leacy (ed.), Catalogue No. 11-516E, Ottawa.
Statistics Canada, 1994, *Human Activity and the Environment 1994*, Catalogue No.11-509E, Ottawa.
Statistics Canada, CANSIM, matrix 1.

Population density

If Canada's 1996 population of 30 million people were evenly distributed over its entire 10 million km², the average population density would be 3 persons per km² (Table 4.1.4). In comparison, the population density was 0.6 persons per km² in 1901 and 1.5 persons per km² in 1951.

The Maritime provinces, specifically Prince Edward Island, have traditionally had the highest population densities.

Canada's population density has increased five-fold since the beginning of the 20th century, doubling since 1951. However, our population density remains very low when compared to other countries; it is the third-lowest amongst OECD countries, after Australia (2.4 per km²) and Iceland (2.6 per km²).[1]

Despite its overall low density, the Canadian population is concentrated in specific areas of the country (Map 4.1.2 and Table 4.1.5). This concentration is largely the result of the urbanization process, which has induced a large proportion of the Canadian population to live in cities.

Urbanization and census metropolitan areas

The results from the first post-Confederation census in 1871 indicate that the largest share of the Canadian population lived in smaller urban centres. Cities of fewer than 30 000 accounted for 66% of the total urban population, whereas urban centres of over 100 000 accounted for only 17% (Table 4.1.6). However, these larger cities grew at a much quicker pace than their smaller counterparts. By 1996, larger urban centres accounted for 71% of total urban population, compared with 17% for

1. Organisation for Economic Co-operation and Development (OECD), 1998, *Towards Sustainable Development: Environmental Indicators*, Paris.

Table 4.1.5
Rural and Urban Population by Provincial and Territorial Drainage Sub-basin, 1976, 1986 and 1996

	Total population			Rural population			Urban population			Urban population as a percentage of total		
Province/Territory and sub-basin	1976	1986	1996	1976	1986	1996	1976	1986	1996	1976	1986	1996
	persons									percent		
Canada	**22 992 603**	**25 309 331**	**28 846 761**	**5 625 634**	**5 957 244**	**6 385 551**	**17 366 969**	**19 352 087**	**22 461 210**	**75.5**	**76.5**	**77.9**
Newfoundland												
Little Mecatina and Strait of Belle Isle	2 165	2 340	2 062	2 165	2 340	2 062	-	-	-	-	-	-
North Newfoundland	207 619	203 986	188 929	99 067	102 401	99 659	108 552	101 585	89 270	52.3	49.8	47.2
South Newfoundland	317 054	335 622	333 673	119 268	119 038	127 977	197 786	216 584	205 696	62.4	64.5	61.6
North Labrador	2 018	2 440	2 563	2 018	2 440	2 563	-	-	-	-	-	-
Churchill	24 886	19 502	19 922	2 955	2 939	1 069	21 931	16 563	18 853	88.1	84.9	94.6
Naskaupi and Central Labrador	1 263	1 470	1 767	1 263	1 470	1 767	-	-	-	-	-	-
Eagle and South Labrador	2 720	2 989	2 876	2 720	2 989	2 876	-	-	-	-	-	-
Total	**557 725**	**568 349**	**551 792**	**229 456**	**233 617**	**237 973**	**328 269**	**334 732**	**313 819**	**58.9**	**58.9**	**56.9**
Prince Edward Island												
Prince Edward Island	118 229	126 646	134 557	74 350	78 357	75 097	43 879	48 289	59 460	37.1	38.1	44.2
Total	**118 229**	**126 646**	**134 557**	**74 350**	**78 357**	**75 097**	**43 879**	**48 289**	**59 460**	**37.1**	**38.1**	**44.2**
Nova Scotia												
Bay of Fundy	288 822	312 684	330 730	174 223	195 388	205 078	114 599	117 296	125 652	39.7	37.5	38.0
Southeast Atlantic Ocean	369 677	394 376	420 281	128 312	137 648	140 737	241 365	256 728	279 544	65.3	65.1	66.5
Cape Breton Island	170 072	166 116	158 271	63 448	69 013	65 609	106 624	97 103	92 662	62.7	58.5	58.5
Total	**828 571**	**873 176**	**909 282**	**365 983**	**402 049**	**411 424**	**462 588**	**471 127**	**497 858**	**55.8**	**54.0**	**54.8**
New Brunswick												
Saint John and South Bay of Fundy	340 280	353 966	373 631	145 429	159 962	174 401	194 851	194 004	199 230	57.3	54.8	53.3
Gulf of St. Lawrence and North Bay of Fundy	336 969	355 476	364 502	177 402	199 177	203 311	159 567	156 299	161 191	47.4	44.0	44.2
Total	**677 249**	**709 442**	**738 133**	**322 831**	**359 139**	**377 712**	**354 418**	**350 303**	**360 421**	**52.3**	**49.4**	**48.8**

Table 4.1.5

Rural and Urban Population by Provincial and Territorial Drainage Sub-basin, 1976, 1986 and 1996 (continued)

Province/Territory and sub-basin	Total population 1976	Total population 1986	Total population 1996	Rural population 1976	Rural population 1986	Rural population 1996	Urban population 1976	Urban population 1986	Urban population 1996	Urban population as a percentage of total 1976	Urban population as a percentage of total 1986	Urban population as a percentage of total 1996
	persons									percent		
Quebec												
Saint-Jean	39 144	39 351	35 626	27 959	31 864	28 349	11 185	7 487	7 277	28.6	19.0	20.4
Cascapédia and Gulf of St. Lawrence	94 740	92 835	87 262	62 689	62 025	62 742	32 051	30 810	24 520	33.8	33.2	28.1
Upper Ottawa	59 071	59 163	63 139	28 141	29 678	32 478	30 930	29 485	30 661	52.4	49.8	48.6
Coulonge and Central Ottawa	42 737	45 535	52 325	15 601	17 116	17 728	27 136	28 419	34 597	63.5	62.4	66.1
Gatineau and Lower Ottawa	352 534	377 486	464 372	121 630	141 889	180 631	230 904	235 597	283 741	65.5	62.4	61.1
Upper St. Lawrence	70 265	71 767	78 822	23 023	22 865	27 100	47 242	48 902	51 722	67.2	68.1	65.6
St-Maurice	168 024	175 080	174 899	18 971	28 994	25 451	149 053	146 086	149 448	88.7	83.4	85.5
Central St. Lawrence	3 765 458	3 945 681	4 386 965	486 280	526 240	592 159	3 279 178	3 419 441	3 794 806	87.1	86.7	86.5
Lower St. Lawrence	984 942	1 055 110	1 124 914	283 123	321 789	316 063	701 819	733 321	808 851	71.2	69.5	71.9
North Gaspé Peninsula	139 226	141 881	137 358	66 485	69 026	66 423	72 741	72 855	70 935	52.2	51.4	51.6
Saguenay	272 053	287 297	289 845	76 132	87 928	88 413	195 921	199 369	201 432	72.0	69.4	69.5
Betsiamites	15 074	14 897	13 075	9 523	9 673	7 738	5 551	5 224	5 337	36.8	35.1	40.8
Manicouagan and Aux Outardes	24 395	20 159	20 491	4 145	4 152	4 710	20 250	16 007	15 781	83.0	79.4	77.0
Moisie and St. Lawrence Estuary	60 800	53 822	52 843	10 197	8 920	8 490	50 603	44 902	44 353	83.2	83.4	83.9
Romaine and Gulf of St. Lawrence	5 213	5 369	5 213	1 992	2 253	2 193	3 221	3 116	3 020	61.8	58.0	57.9
Natashquan and Gulf of St. Lawrence	16 855	18 040	16 667	11 987	16 469	15 006	4 868	1 571	1 661	28.9	8.7	10.0
Little Mecatina	3 749	4 198	4 606	3 749	4 198	4 606	-	-	-	-	-	-
Nottaway	32 225	29 408	26 985	7 059	6 185	6 788	25 166	23 223	20 197	78.1	79.0	74.8
Broadback and Rupert	2 368	3 521	4 370	2 368	3 521	4 370	-	-	-	-	-	-
Eastmain	326	361	527	326	361	527	-	-	-	-	-	-
Fort George and Sakami	3 804	3 543	4 762	3 804	3 543	4 762	-	-	-	-	-	-
Great Whale and Southeast Hudson Bay	661	1 045	1 339	661	1 045	1 339	-	-	-	-	-	-
Little Whale and East Hudson Bay	-	59	315	-	59	315	-	-	-	-	-	-
Northeast Hudson Bay	1 231	2 191	3 038	1 231	2 191	3 038	-	-	-	-	-	-
West Ungava Bay	622	1 493	2 059	622	1 493	2 059	-	-	-	-	-	-
Aux Feuilles	671	245	350	671	245	350	-	-	-	-	-	-
Koksoak	372	1 066	1 726	372	1 066	1 726	-	-	-	-	-	-
Caniapiskau	4 735	1 071	1 212	1 306	795	1 212	3 429	276	-	72.4	25.8	-
East Ungava Bay	285	383	648	285	383	648	-	-	-	-	-	-
Abitibi and North French	24 472	24 027	23 827	16 341	15 530	14 086	8 131	8 497	9 741	33.2	35.4	40.9
Harricana	48 393	56 377	59 215	15 016	21 970	19 670	33 377	34 407	39 545	69.0	61.0	66.8
Total	**6 234 445**	**6 532 461**	**7 138 795**	**1 301 689**	**1 443 466**	**1 541 170**	**4 932 756**	**5 088 995**	**5 597 625**	**79.1**	**77.9**	**78.4**
Ontario												
Nipigon and Northwest Lake Superior	131 457	134 422	137 547	19 368	22 342	28 433	112 089	112 080	109 114	85.3	83.4	79.3
Northeast Lake Superior	44 473	41 946	40 962	13 422	13 386	12 797	31 051	28 560	28 165	69.8	68.1	68.8
North Lake Huron	265 378	262 391	266 106	50 551	46 770	48 166	214 827	215 621	217 940	81.0	82.2	81.9
Wanipitai and French	95 577	86 957	98 718	32 913	30 870	36 352	62 664	56 087	62 366	65.6	64.5	63.2
East Georgian Bay	381 184	441 470	613 482	178 550	186 183	235 634	202 634	255 287	377 848	53.2	57.8	61.6
East Lake Huron	244 651	262 299	293 958	140 812	138 709	154 157	103 839	123 590	139 801	42.4	47.1	47.6
North Lake Erie	1 618 825	1 705 471	1 958 489	395 068	376 114	388 543	1 223 757	1 329 357	1 569 946	75.6	78.0	80.2
Lake Ontario	4 294 139	4 867 883	5 863 693	396 190	455 309	476 121	3 897 949	4 412 574	5 387 572	90.8	90.7	91.9
Montréal and Upper Ottawa	60 286	62 448	60 529	20 849	21 102	23 768	39 437	41 346	36 761	65.4	66.2	60.7
Madawaska, Petawawa and Central Ottawa	227 183	242 772	287 412	67 093	79 927	95 181	160 090	162 845	192 231	70.5	67.1	66.9
Rideau and Lower Ottawa	532 931	621 606	739 341	110 123	125 531	145 636	422 808	496 075	593 705	79.3	79.8	80.3
Upper St. Lawrence	172 951	187 305	200 712	59 110	66 259	72 005	113 841	121 046	128 707	65.8	64.6	64.1
Nisksibi and Central Hudson Bay	226	267	362	226	267	362	-	-	-	-	-	-
Severn	3 221	308	4 267	3 221	308	4 267	-	-	-	-	-	-
Winisk	1 169	1 055	2 297	1 169	1 055	2 297	-	-	-	-	-	-
Attawapiskat	973	490	2 037	973	490	779	-	-	1 258	-	-	61.8
Upper Albany	3 063	1 051	1 543	3 063	1 051	1 543	-	-	-	-	-	-
Lower Albany	981	-	1 605	981	-	1 605	-	-	-	-	-	-
Kenogami	9 979	10 047	8 656	3 209	2 995	2 497	6 770	7 052	6 159	67.8	70.2	71.2
Kwataboahegan	1 918	1 328	3 164	553	228	-	1 365	1 100	3 164	71.2	82.8	100.0
Moose	67 721	66 764	63 715	15 364	18 528	15 469	52 357	48 236	48 246	77.3	72.2	75.7
Abitibi	30 667	29 284	28 563	12 020	10 829	10 174	18 647	18 455	18 389	60.8	63.0	64.4
Harricana	775	599	901	775	599	-	-	-	901	-	-	100.0
Upper Winnipeg	45 599	43 572	44 671	16 993	18 011	19 829	28 606	25 561	24 842	62.7	58.7	55.6
English	28 366	28 747	29 383	12 577	14 199	17 757	15 789	14 548	11 626	55.7	50.6	39.6
East Lake Winnipeg	772	1 212	1 460	772	1 212	1 460	-	-	-	-	-	-
Total	**8 264 465**	**9 101 694**	**10 753 573**	**1 555 945**	**1 632 274**	**1 794 832**	**6 708 520**	**7 469 420**	**8 958 741**	**81.2**	**82.1**	**83.3**

Table 4.1.5
Rural and Urban Population by Provincial and Territorial Drainage Sub-basin, 1976, 1986 and 1996 (continued)

Province/Territory and sub-basin	Total population 1976	1986	1996	Rural population 1976	1986	1996	Urban population 1976	1986	1996	Urban population as a percentage of total 1976	1986	1996
	persons									percent		
Manitoba												
Hayes	5 709	7 647	9 438	5 709	7 647	9 438	-	-	-	-	-	-
Qu'Appelle	-	-	382	-	-	382	-	-	-	-	-	-
Saskatchewan	22 462	21 784	21 299	8 685	8 025	8 565	13 777	13 759	12 734	61.3	63.2	59.8
Lake Winnipegosis and Lake Manitoba	79 798	73 761	73 041	60 274	54 510	55 260	19 524	19 251	17 781	24.5	26.1	24.3
Assiniboine	256 451	240 842	233 574	52 991	51 466	51 238	203 460	189 376	182 336	79.3	78.6	78.1
Souris	17 527	16 458	14 416	13 627	12 334	10 610	3 900	4 124	3 806	22.2	25.1	26.4
Red	560 151	628 356	678 696	115 049	114 663	122 705	445 102	513 693	555 991	79.5	81.8	81.9
Winnipeg	13 045	11 539	12 799	10 014	8 448	10 060	3 031	3 091	2 739	23.2	26.8	21.4
East Lake Winnipeg	3 597	4 062	4 285	3 597	4 062	4 285	-	-	-	-	-	-
West Lake Winnipeg	22 616	23 140	28 710	18 535	18 924	23 412	4 081	4 216	5 298	18.0	18.2	18.4
Rat and Grass	21 864	18 952	18 731	2 980	2 479	3 084	18 884	16 473	15 647	86.4	86.9	83.5
Nelson	8 626	8 766	11 189	8 626	7 539	10 031	-	1 227	1 158	-	14.0	10.3
Reindeer Lake	525	999	1 107	525	999	1 107	-	-	-	-	-	-
Central Churchill	6 990	5 275	4 804	4 469	3 633	3 304	2 521	1 642	1 500	36.1	31.1	31.2
Lower Churchill and West Hudson Bay	2 145	1 217	1 089	1 943	1 217	16	202	-	1 073	9.4	-	98.5
Seal and West Hudson Bay	-	218	338	-	218	338	-	-	-	-	-	-
Total	1 021 506	1 063 016	1 113 898	307 024	296 164	313 835	714 482	766 852	800 063	69.9	72.1	71.8
Saskatchewan												
Upper South Saskatchewan	668	619	426	668	619	426	-	-	-	-	-	-
Red Deer	-	-	7	-	-	7	-	-	-	-	-	-
Central North Saskatchewan	36 856	43 530	42 864	19 205	21 483	19 507	17 651	22 047	23 357	47.9	50.6	54.5
Battle	7 479	8 810	7 764	4 910	4 993	6 205	2 569	3 817	1 559	34.4	43.3	20.1
Lower North Saskatchewan	94 907	101 367	95 141	51 681	51 147	42 101	43 226	50 220	53 040	45.5	49.5	55.8
Lower South Saskatchewan	226 800	274 258	284 083	65 267	62 753	58 875	161 533	211 505	225 208	71.2	77.1	79.3
Qu'Appelle	299 661	326 130	320 688	95 722	87 321	81 677	203 939	238 809	239 011	68.1	73.2	74.5
Saskatchewan	49 951	50 188	47 640	33 179	30 634	30 446	16 772	19 554	17 194	33.6	39.0	36.1
Lake Winnipegosis and Lake Manitoba	21 655	19 996	15 525	18 322	16 788	12 600	3 333	3 208	2 925	15.4	16.0	18.8
Assiniboine	80 088	76 723	66 797	46 979	41 974	34 653	33 109	34 749	32 144	41.3	45.3	48.1
Souris	59 819	60 428	56 195	37 723	34 630	31 232	22 096	25 798	24 963	36.9	42.7	44.4
Beaver	18 605	19 925	21 791	14 943	15 949	16 978	3 662	3 976	4 813	19.7	19.9	22.1
Upper Churchill	6 012	6 496	7 826	4 348	3 843	7 826	1 664	2 653	-	27.7	40.8	0.0
Upper Central Churchill	4 761	7 375	9 605	4 761	4 679	6 641	-	2 696	2 964	-	36.6	30.9
Reindeer Lake	668	1 341	2 032	668	1 341	2 032	-	-	-	-	-	-
Central Churchill	-	877	959	-	877	959	-	-	-	-	-	-
Lower Central Athabasca	8	21	39	8	21	39	-	-	-	-	-	-
Fond du Lac	776	1 663	2 034	776	1 663	2 034	-	-	-	-	-	-
Athabasca Lake	2 546	221	240	769	62	240	1 777	159	-	69.8	72.0	-
Missouri	10 063	9 645	8 581	10 063	8 639	8 581	-	1 006	-	-	10.4	-
Total	921 323	1 009 613	990 237	409 992	389 416	363 059	511 331	620 197	627 178	55.5	61.4	63.3
Alberta												
Upper South Saskatchewan	171 068	197 470	217 371	54 701	55 056	60 532	116 367	142 414	156 839	68.0	72.1	72.2
Bow	530 063	724 193	890 477	36 787	36 646	50 630	493 276	687 547	839 847	93.1	94.9	94.3
Red Deer	132 114	172 859	196 925	76 529	79 211	91 396	55 585	93 648	105 529	42.1	54.2	53.6
Upper North Saskatchewan	234 331	282 814	316 165	30 896	34 940	42 452	203 435	247 874	273 713	86.8	87.7	86.6
Central North Saskatchewan	457 775	593 080	652 060	88 600	96 984	109 592	369 175	496 096	542 468	80.7	83.7	83.2
Battle	85 852	99 667	104 066	49 974	49 334	49 429	35 878	50 333	54 637	41.8	50.5	52.5
Lower North Saskatchewan	8 661	8 460	8 308	7 129	6 735	6 404	1 532	1 725	1 904	17.7	20.4	22.9
Lower South Saskatchewan	267	214	208	267	214	208	-	-	-	-	-	-
Beaver	24 607	31 386	35 344	12 191	14 872	18 536	12 416	16 514	16 808	50.5	52.6	47.6
Upper Athabasca	27 020	35 687	40 956	10 367	7 853	9 972	16 653	27 834	30 984	61.6	78.0	75.7
Pembina and Central Athabasca	45 642	53 711	57 026	30 358	34 240	35 167	15 284	19 471	21 859	33.5	36.2	38.3
Lower Central Athabasca	24 759	43 632	42 975	7 381	7 991	9 117	17 378	35 641	33 858	70.2	81.7	78.8
Lower Athabasca	70	2 557	3 051	70	298	581	-	2 259	2 470	-	88.3	81.0
Upper Peace	16 690	19 329	19 315	11 757	12 666	12 226	4 933	6 663	7 089	29.6	34.5	36.7
Smoky	48 239	62 250	70 830	20 759	23 940	25 015	27 480	38 310	45 815	57.0	61.5	64.7
Central Peace	16 847	19 405	18 845	9 824	10 980	12 943	7 023	8 425	5 902	41.7	43.4	31.3
Lower Central Peace	7 322	11 842	14 107	5 760	8 838	11 014	1 562	3 004	3 093	21.3	25.4	21.9
Lower Peace and Lake Claire	681	1 093	1 660	681	1 093	1 660	-	-	-	-	-	-
Athabasca Lake	1 189	1 017	1 053	-	1 017	1 053	1 189	-	-	100.0	-	-
Slave	21	15	19	21	15	19	-	-	-	-	-	-
Buffalo	-	1	-	-	1	-	-	-	-	-	100.0	-
Upper Hay	1 641	2 047	3 153	1 641	2 047	3 153	-	-	-	-	-	-
Missouri	3 178	3 096	2 912	3 178	3 096	2 912	-	-	-	-	-	-
Total	1 838 037	2 365 825	2 696 826	458 871	488 067	554 011	1 379 166	1 877 758	2 142 815	75.0	79.4	79.5

Table 4.1.5

Rural and Urban Population by Provincial and Territorial Drainage Sub-basin, 1976, 1986 and 1996 (continued)

Province/Territory and sub-basin	Total population			Rural population			Urban population			Urban population as a percentage of total		
	1976	1986	1996	1976	1986	1996	1976	1986	1996	1976	1986	1996
	persons									percent		
British Columbia												
Williston Lake	7 864	7 977	7 304	2 502	2 607	1 675	5 362	5 370	5 629	68.2	67.3	77.1
Upper Peace	38 921	50 303	55 548	17 959	24 332	22 680	20 962	25 971	32 868	53.9	51.6	59.2
Smoky	-	-	276	-	-	276	-	-	-	-	-	-
Upper Hay	488	327	307	488	327	307	-	-	-	-	-	-
Taku and North Pacific Ocean	-	21	24	-	21	24	-	-	-	-	-	-
Stikine	570	685	889	570	685	889	-	-	-	-	-	-
Nass and North Central Pacific Ocean	2 907	2 666	2 985	2 907	2 666	2 127	-	-	858	-	-	28.7
Skeena	52 897	57 574	65 117	20 585	20 592	22 680	32 312	36 982	42 437	61.1	64.2	65.2
Gardner Canal and Central Pacific Ocean	17 929	15 844	16 892	4 702	5 096	6 341	13 227	10 748	10 551	73.8	67.8	62.5
Knight Inlet and South Pacific Ocean	196 558	194 520	240 406	24 102	26 252	29 721	172 456	168 268	210 685	87.7	86.5	87.6
Vancouver Island	442 217	517 380	655 920	128 814	130 403	158 145	313 403	386 977	497 775	70.9	74.8	75.9
Nechako	67 948	74 257	78 078	16 762	20 337	22 213	51 186	53 920	55 865	75.3	72.6	71.5
Upper Fraser	46 661	55 001	63 967	28 992	30 458	32 318	17 669	24 543	31 649	37.9	44.6	49.5
Thompson	123 600	136 225	169 847	60 064	59 380	65 905	63 536	76 845	103 942	51.4	56.4	61.2
Fraser	1 149 683	1 414 524	1 918 265	128 319	128 445	135 438	1 021 364	1 286 079	1 782 827	88.8	90.9	92.9
Columbia	306 333	343 601	436 288	124 449	138 029	159 653	181 884	205 572	276 635	59.4	59.8	63.4
Queen Charlotte Islands	5 509	5 480	5 598	5 509	5 480	4 332	-	-	1 266	-	-	22.6
Skagit	1 006	-	112	1 006	-	112	-	-	-	-	-	-
Upper Yukon	558	531	499	558	531	499	-	-	-	-	-	-
Upper Liard	1 008	1 583	584	199	1 583	584	809	-	-	80.3	-	-
Central Liard	195	55	103	195	55	103	-	-	-	-	-	-
Fort Nelson	3 756	4 813	5 491	840	1 084	1 090	2 916	3 729	4 401	77.6	77.5	80.2
Total	**2 466 608**	**2 883 367**	**3 724 500**	**569 522**	**598 363**	**667 112**	**1 897 086**	**2 285 004**	**3 057 388**	**76.9**	**79.2**	**82.1**
Yukon Territory												
Alsek	268	525	764	268	525	764	-	-	-	-	-	-
Upper Yukon	14 965	17 919	23 209	1 654	2 720	6 013	13 311	15 199	17 196	89.0	84.8	74.1
Pelly	1 920	993	1 886	1 920	993	635	-	-	1 251	-	-	66.3
Upper Central Yukon	317	112	167	317	112	167	-	-	-	-	-	-
Stewart	1 535	896	559	1 535	896	559	-	-	-	-	-	-
Central Yukon	1 209	1 374	2 003	1 209	1 374	2 003	-	-	-	-	-	-
Porcupine	224	232	278	224	232	278	-	-	-	-	-	-
Tanana	-	113	131	-	113	131	-	-	-	-	-	-
Upper Liard	1 394	1 340	1 737	1 394	1 340	1 737	-	-	-	-	-	-
Peel and Northwest Arctic Ocean	4	-	32	4	-	32	-	-	-	-	-	-
Total	**21 836**	**23 504**	**30 766**	**8 525**	**8 305**	**12 319**	**13 311**	**15 199**	**18 447**	**61.0**	**64.7**	**60.0**
Northwest Territories												
Dubawnt Lake	19	-	-	19	-	-	-	-	-	-	-	-
Lower Thelon	1 106	1 304	1 722	1 106	1 304	1 722	-	-	-	-	-	-
Northwest Central Hudson Bay	1 879	2 773	3 918	1 879	2 773	1 860	-	-	2 058	-	-	52.5
Northwest Hudson Bay	265	433	559	265	433	559	-	-	-	-	-	-
Southampton Island	728	899	1 300	728	899	1 300	-	-	-	-	-	-
Slave	2 789	2 921	2 452	501	484	2 452	2 288	2 437	-	82.0	83.4	-
Hay	2 434	2 659	3 368	182	98	481	2 252	2 561	2 887	92.5	96.3	85.7
Buffalo	2 151	1 738	555	236	180	555	1 915	1 558	-	89.0	89.6	-
Taltson and Southeast Great Slave Lake	224	273	307	224	273	307	-	-	-	-	-	-
Yellowknife and Northeast Great Slave Lake	9 414	13 394	19 266	1 158	2 469	5 239	8 256	10 925	14 027	87.7	81.6	72.8
Marian	431	468	418	431	468	418	-	-	-	-	-	-
West Great Slave Lake	1 016	579	699	-	176	699	1 016	403	-	100.0	69.6	-
Lower Liard	619	948	587	619	948	587	-	-	-	-	-	-
Upper Mackenzie	816	794	869	816	794	869	-	-	-	-	-	-
Upper Central Mackenzie	1 136	987	1 281	1 136	987	1 281	-	-	-	-	-	-
Central Mackenzie	143	174	167	143	174	167	-	-	-	-	-	-
Great Bear	910	1 053	1 322	910	1 053	1 322	-	-	-	-	-	-
Lower Central Mackenzie	367	627	798	367	627	798	-	-	-	-	-	-
Lower Mackenzie	3 680	4 059	4 109	564	670	847	3 116	3 389	3 262	84.7	83.5	79.4
Peel and Northwest Arctic Ocean	1 491	1 523	1 605	1 491	1 523	1 605	-	-	-	-	-	
Anderson and West Arctic Ocean	700	981	1 033	700	981	1 033	-	-	-	-	-	
Amundsen Gulf	128	193	278	128	193	278	-	-	-	-	-	
Coppermine	758	925	1 201	758	925	1 201	-	-	-	-	-	
Coronation Gulf and Dease Strait	-	77	69	-	77	69	-	-	-	-	-	
Back and Queen Maud Gulf	73	-	-	73	-	-	-	-	-	-	-	
Gulf of Boothia	1 651	2 093	2 861	1 651	2 093	2 861	-	-	-	-	-	

Table 4.1.5
Rural and Urban Population by Provincial and Territorial Drainage Sub-basin, 1976, 1986 and 1996 (continued)

Province/Territory and sub-basin	Total population			Rural population			Urban population			Urban population as a percentage of total		
	1976	1986	1996	1976	1986	1996	1976	1986	1996	1976	1986	1996
	persons									percent		
Banks and Victoria Islands	1 463	2 120	2 842	1 463	2 120	2 842	-	-	-	-	-	-
Foxe Basin	5 874	7 818	10 294	3 554	4 880	5 133	2 320	2 938	5 161	39.5	37.6	50.1
Viscount Melville Sound	344	425	522	344	425	522	-	-	-	-	-	-
Total	**42 609**	**52 238**	**64 402**	**21 446**	**28 027**	**37 007**	**21 163**	**24 211**	**27 395**	**49.7**	**46.4**	**42.5**
Canada	**22 992 603**	**25 309 331**	**28 846 761**	**5 625 634**	**5 957 244**	**6 385 551**	**17 366 969**	**19 352 087**	**22 461 210**	**75.5**	**76.5**	**77.9**

Notes:
See section 3.1-**Environmental geographies** for hydrological classification codes and area figures for these sub-basins.
The population figures presented here are not adjusted for net undercoverage and non-permanent residents.
Sources:
Statistics Canada, Environment Accounts and Statistics Division, and Census of Population.

Table 4.1.6
Population in Cities of 1 000 Persons and Over by Size, 1871, 1901, 1951 and 1996

City size	Population				As share of total urban population			
	1871	1901	1951	1996	1871	1901	1951	1996
	persons				percent			
1 000 to 4 999	196 000	545 037	1 155 584	1 391 884	30.3	29.2	15.4	6.2
5 000 to 29 000	228 354	503 187	1 947 128	2 502 721	35.3	26.9	25.9	11.2
30 000 to 99 999	115 791	343 266	1 147 888	2 655 437	17.9	18.4	15.3	11.8
100 000 and over	107 225	475 770	3 260 939	15 894 691	16.6	25.5	43.4	70.8
Total urban population	**647 370**	**1 867 260**	**7 511 539**	**22 444 733**	**100.0**	**100.0**	**100.0**	**100.0**

Sources:
Statistics Canada, 1983, *Historical Statistics of Canada*, Second Edition, F.H. Leacy (ed.), Catalogue No. 11-516E, Ottawa.
Statistics Canada, 1997, *GeoRef User's Guide: 1996 Census*, Catalogue No. 92F0085XCB, Ottawa.

centres with fewer than 30 000 people. As a consequence, the urban landscape was significantly different in 1996 from what it was in 1871 (Figure 4.1.2).

Canada's population is becoming increasingly centralized in its largest cities, the census metropolitan areas (CMAs[1]). Canadian CMAs accounted for 55% of the total population in 1976, and for 62% in 1996. The two largest CMAs, Toronto and Montréal, accounted for 44% of the total CMA population in 1976, and 42% in 1996 (Table 4.1.7). Over this period, Toronto's share of the total CMA population increased from 22% to 24% while, in contrast, Montréal's share decreased from 22% to 18%. The other CMA that stands out for its demographic importance is Vancouver, with 10% of the total Canadian population in 1996.

4.1.2 Components of population growth

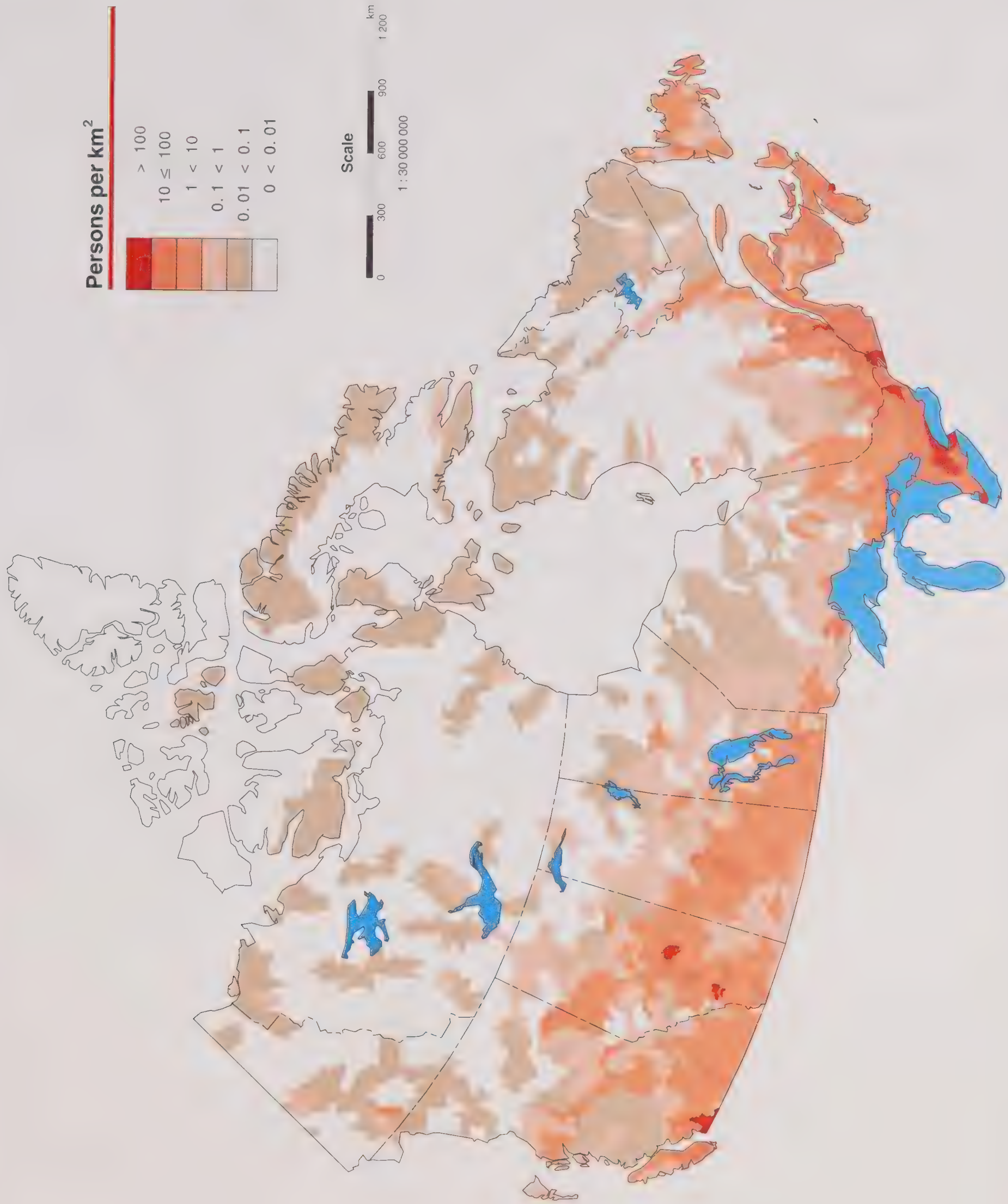
The growth of Canada's population is the result of two factors: natural increase and net migration. However, to obtain an exact population number, one needs to consider temporary residents and returning Canadians as well. Together, these elements are known as the components of population growth (Table 4.1.8).

Figure 4.1.2
Population in Cities of 1 000 Persons and Over by Size, 1871, 1901, 1951 and 1996

Source:
Statistics Canada, 1997, *GeoRef User's Guide: 1996 Census*, Catalogue No. 92F0085XCB, Ottawa.

1. The general concept of a CMA is one of a very large urban core, together with adjacent suburban and rural areas which have a high degree of economic and social integration with the urban core. A CMA is delineated around an urbanized core having a population of at least 100 000 (based on the previous census).

Map 4.1.2
Population Density by Sub-sub-basin, 1996



Sources:
Statistics Canada, Environment Accounts and Statistics Division, and Census of Population.

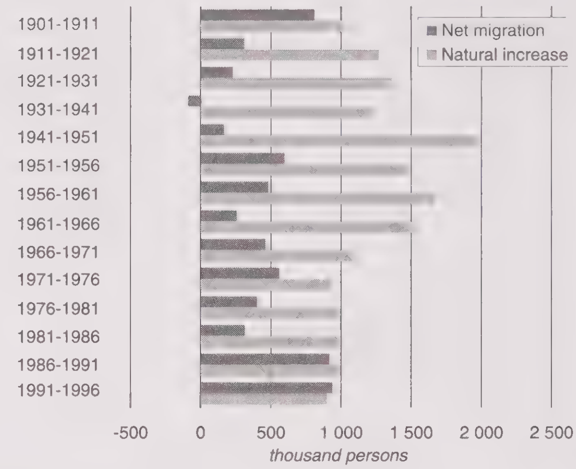
Since 1901, the largest component of population growth has been natural increase, accounting for 73% of population increase. Since 1986, however, the composition of population growth has been changing. Immigration is becoming more important, accounting for approximately half of the increase (Figure 4.1.3).

Natural increase

Natural increase is the number of births minus the number of deaths. The fertility rate—the average number of children a woman will give birth to in her lifetime—dropped from 3.9 in the late 1950s to 1.6 in 1980. It has fluctuated close to this figure since then. The decline in the fertility rate is further amplified by demographics in Canada. Because the large baby boom population cohort is now moving out of child-bearing age, there are fewer women left to have babies (Figure 4.1.5). Since the number of deaths will also increase because of the aging of the population, it is likely that by the year 2020, Canada's natural increase will approach zero. Any population growth thereafter would rely exclusively on immigration.[1]

1. Statistics Canada, 1998, *Annual Demographic Statistics, 1997*, Catalogue No. 91-213-XPB, Ottawa.

Figure 4.1.3
Components of Population Growth: Natural Increase and Net Migration, 1901-1997



Source:
Statistics Canada, Demography Division.

Table 4.1.7
Estimates of Population for Census Metropolitan Areas, 1976, 1986 and 1996

Census metropolitan area	Population			As share of total population of all CMAs		
	1976	1986	1996	1976	1986	1996
	thousands			percent		
Calgary	469.9	692.1	851.6	3.7	4.4	4.6
Chicoutimi-Jonquière	128.6	162.4	166.6	1.0	1.0	0.9
Edmonton	554.2	797.7	891.5	4.3	5.1	4.8
Halifax	268.0	303.6	346.8	2.1	1.9	1.9
Hamilton	529.4	577.1	650.4	4.1	3.7	3.5
Kitchener	272.2	322.6	403.3	2.1	2.0	2.2
London	270.4	355.0	416.1	2.1	2.3	2.3
Montréal	2 802.5	3 032.0	3 359.0	21.9	19.3	18.2
Oshawa	135.2	210.5	280.9	1.1	1.3	1.5
Ottawa-Hull	693.3	848.7	1 030.5	5.4	5.4	5.6
Québec	542.2	619.1	697.6	4.2	3.9	3.8
Regina	151.2	191.2	199.2	1.2	1.2	1.1
St. Catharines-Niagara	301.9	354.4	389.7	2.4	2.3	2.1
St. John's	143.4	165.1	177.8	1.1	1.0	1.0
Saint John	113.0	124.1	129.1	0.9	0.8	0.7
Saskatoon	133.8	206.2	222.1	1.0	1.3	1.2
Sherbrooke	-	133.6	150.0	...	0.8	0.8
Sudbury	157.0	153.3	166.2	1.2	1.0	0.9
Thunder Bay	119.3	126.0	131.3	0.9	0.8	0.7
Toronto	2 803.1	3 607.6	4 444.7	21.9	22.9	24.1
Trois-Rivières	-	132.1	143.6	...	0.8	0.8
Vancouver	1 166.3	1 451.6	1 891.4	9.1	9.2	10.3
Victoria	218.3	266.7	313.4	1.7	1.7	1.7
Windsor	247.6	263.0	291.7	1.9	1.7	1.6
Winnipeg	578.2	640.6	676.7	4.5	4.1	3.7
Total	**12 798.8**	**15 736.3**	**18 421.2**	**100.0**	**100.0**	**100.0**

Source:
Statistics Canada, CANSIM, matrices 6231 and 6496.

Table 4.1.8
Components of Population Growth, 1960-1998

Year	Population			Natural increase			Net migration		
	Total	Growth	Growth rate	Births	Deaths	Natural increase	Immigration	Emigration	Net migration
	thousands		percent	thousands			thousands		
1960	17 909.0	362.0	2.0	478.6	139.7	338.9	104.1	75.6	28.5
1961	18 271.0	343.0	1.9	475.7	141.0	334.7	71.7	72.3	-0.6
1962	18 614.0	350.0	1.9	469.7	143.7	326.0	74.6	76.7	-2.1
1963	18 964.0	361.0	1.9	465.8	147.4	318.4	93.2	83.6	9.6
1964	19 325.0	353.0	1.8	452.9	145.9	307.0	112.6	92.4	20.2
1965	19 678.0	370.0	1.9	418.6	148.9	269.7	146.8	105.3	41.5
1966	20 048.0	364.0	1.8	387.7	149.9	237.8	194.7	91.5	103.2
1967	20 412.0	317.0	1.6	370.9	150.3	220.6	222.9	108.5	114.4
1968	20 729.0	299.0	1.4	364.3	153.2	211.1	184.0	100.0	84.0
1969	21 028.0	296.0	1.4	369.7	154.5	215.2	161.5	90.1	71.4
1970	21 324.0	638.1	3.0	372.0	156.0	216.0	147.7	81.0	66.7
1971	21 962.1	257.5	1.2	362.2	157.3	204.9	121.9	70.1	51.8
1972	22 219.6	274.3	1.2	351.3	159.5	191.7	117.0	66.0	51.0
1973	22 493.8	314.6	1.4	345.8	162.6	183.2	138.5	63.9	74.7
1974	22 808.4	333.8	1.5	339.9	166.3	173.6	217.5	83.5	134.0
1975	23 142.3	307.5	1.3	353.5	168.8	184.8	209.3	78.0	131.3
1976	23 449.8	276.6	1.2	364.3	166.4	197.9	170.0	66.7	103.3
1977	23 726.3	237.6	1.0	358.3	165.7	192.5	130.9	57.8	73.1
1978	23 964.0	238.2	1.0	360.0	169.0	190.9	101.0	63.3	37.6
1979	24 202.2	314.1	1.3	362.2	165.8	196.4	84.5	62.4	22.2
1980	24 516.3	304.1	1.2	367.3	171.5	195.8	143.6	49.9	93.7
1981	24 820.4	297.0	1.2	372.1	170.5	201.6	127.0	44.9	82.1
1982	25 117.4	249.5	1.0	372.5	172.4	200.1	135.1	54.8	80.4
1983	25 367.0	240.6	0.9	373.6	176.5	197.1	101.2	59.2	42.0
1984	25 607.6	235.0	0.9	374.5	174.2	200.4	88.3	57.8	30.5
1985	25 842.6	258.0	1.0	376.3	179.1	197.2	83.7	55.2	28.5
1986	26 100.6	349.3	1.3	375.4	183.4	192.0	88.6	50.6	38.0
1987	26 449.9	348.4	1.3	373.0	182.6	190.4	130.8	47.7	83.1
1988	26 798.3	487.9	1.8	370.0	189.9	180.1	152.4	41.0	111.4
1989	27 286.2	414.6	1.5	384.0	188.4	195.6	178.2	40.4	137.8
1990	27 700.9	330.0	1.2	403.3	192.6	210.7	203.0	39.8	163.2
1991	28 030.9	345.7	1.2	402.9	192.4	210.5	219.3	43.7	175.6
1992	28 376.6	326.6	1.2	403.1	197.0	206.1	241.8	45.6	196.2
1993	28 703.1	332.8	1.2	392.2	201.8	190.4	265.4	44.0	221.4
1994	29 036.0	317.9	1.1	386.2	206.5	179.7	234.5	45.3	189.2
1995	29 353.9	318.0	1.1	382.0	209.4	172.6	220.1	47.0	173.1
1996	29 671.9	332.1	1.1	372.4	209.7	162.7	217.0	47.2	169.8
1997	30 004.0	296.5	1.0	365.0	218.2	146.8	224.9	49.6	175.3
1998	30 300.4	...	...	355.3	217.9	137.4	194.4	49.7	144.7

Notes:
Population growth figures do not equal the sum of the natural increase and net migration. One needs to add the balance of non-permanent residents and the number of returning Canadians, as well as a residual.
Sources:
Statistics Canada, 1994, *Human Activity and the Environment 1994*, Catalogue No. 11-509E, Ottawa.
Statistics Canada, 1998, *Annual Demographic Statistics, 1997*, Catalogue No. 91-213-XPB, Ottawa.
Statistics Canada, CANSIM, matrices 1 and 5772-5775.

Net migration

Net migration is the number of arrivals of immigrants minus the number of departures of emigrants. The share of Canadian population represented by immigrants[1] varied between 12% and 22% in the first half of the century before it dropped back to 16% by the 1950s. It then remained virtually stable until the late 1980s, when an intensification of immigration caused the figure to increase to 18%.

Immigrants settle unevenly across Canada, concentrating in Ontario, British Columbia and Quebec. In 1911, 32% of all immigrants settled in Ontario, and by 1996 that figure was up to 55% (Table 4.1.9). In comparison, the second-largest recipient of immigrants, British Columbia, was the home province of 14% of immigrants in 1911, versus 18% in 1996. Quebec had the third-largest share of immigrants in 1996, with 13%. The Prairie provinces, which had been an important destination for immigrants early in the century, represent a constantly decreasing share of Canada's immigrant population: 41% of immigrants had chosen the Prairies in 1911, but in 1996, only 12% settled there.

1. An immigrant is a person who is not a Canadian citizen by birth but who has been granted the right to live in Canada permanently by Canadian immigration authorities.

Table 4.1.9

Share of Immigrant Population by Province and Territory, Selected Years

Province/Territory	1911	1921	1931	1941	1951	1961	1971	1981	1986	1991	1996
						percent					
Newfoundland	...	...	...	...	0.2	0.2	0.3	0.3	0.2	0.2	0.2
Prince Edward Island	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Nova Scotia	2.3	2.2	1.8	2.0	1.4	1.2	1.1	1.1	1.0	0.9	0.8
New Brunswick	1.2	1.1	1.1	1.0	1.0	0.8	0.7	0.7	0.7	0.6	0.5
Quebec	9.3	9.6	10.9	11.1	11.1	13.7	14.2	13.6	13.5	13.6	13.4
Ontario	32.0	32.8	34.9	36.3	41.3	47.6	51.8	52.4	53.3	54.6	54.8
Manitoba	12.0	11.4	10.3	9.6	8.2	6.0	4.6	3.8	3.6	3.2	2.7
Saskatchewan	15.4	15.3	13.8	11.8	8.5	5.3	3.4	2.2	1.8	1.3	1.1
Alberta	13.4	14.0	13.2	12.8	11.7	10.2	8.6	9.4	9.4	8.8	8.2
British Columbia	14.1	13.3	13.8	15.1	16.5	14.9	15.1	16.3	16.1	16.7	18.2
Yukon Territory	0.3	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Northwest Territories	--	--	--	--	0.1	0.1	0.1	0.1	0.1	0.1	0.1

Source:
Statistics Canada, 1997, *Nation Series, Edition 1* (1996 Census of Population CD-ROM), Catalogue No. 93F00020XCB, Ottawa.

Table 4.1.10

Immigrants by Place of Birth and Period of Immigration, 1996

Origin	Immigration					As a percentage of total immigration				
	Before 1961	1961-1970	1971-1980	1981-1990	1991-1996	Before 1961	1961-1970	1971-1980	1981-1990	1991-1996
	persons					percent				
Africa	4 940	25 680	58 155	64 265	76 260	0.5	3.3	5.8	5.9	7.3
Asia	32 580	96 945	328 380	512 160	592 705	3.1	12.3	33.0	46.9	57.0
Caribbean and Bermuda	8 390	45 270	96 025	72 405	57 310	0.8	5.7	9.6	6.6	5.5
Central and South America	6 370	17 410	67 470	106 230	76 340	0.6	2.2	6.8	9.7	7.3
Europe	953 355	543 835	356 700	280 700	197 475	90.4	69.0	35.8	25.7	19.0
Oceania and other	4 245	9 235	15 415	10 235	9 875	0.4	1.2	1.5	0.9	1.0
United States	45 045	50 200	74 015	46 410	29 025	4.3	6.4	7.4	4.2	2.8
Total	**1 054 925**	**788 575**	**996 160**	**1 092 405**	**1 038 990**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Source:
Statistics Canada, 1997, *Nation Series, Edition 1* (1996 Census of Population CD-ROM), Catalogue No. 93F0020XCB, Ottawa.

Immigrants today tend to settle in large urban centres: two-thirds of immigrants who arrived in Canada during the 1980s settled in Toronto, Vancouver and Montréal.[1,2] Immigrants have traditionally come from Europe but are now primarily from Asia (Table 4.1.10). Immigration has had a significant socio-economic impact on our cities.[3]

Interprovincial migration

International immigration is not the only population movement that influences how and where human settlements evolve. Interprovincial (or internal) migration is also a reflection of the prevailing conditions of both natural and built environments, and thus of the growth, or decline, of city size across the country.

In 1996, 315 008 people moved from one province to another (Table 4.1.11). The largest movements occurred in the most populous province: 72 813 people moved into Ontario, but 78 755 moved out. The largest positive balance occurred in British Columbia: most people came from Ontario and Alberta, and the majority of those who left went to these same two provinces. The largest negative balance took place in Quebec, with most of the migrants leaving for Ontario.

Although the number of migrants in 1996 represented a five-year high, the longer-term tendency points to a decline of interprovincial migrants (Table 4.1.12). This is a reflection of a decrease of population movement towards the three most popular destinations: British Columbia, Alberta and Ontario. The tendency is also shaped by a decrease in people leaving Quebec. In brief, Alberta's appeal for interprovincial migrants is becoming strong once again, while net migration in Quebec, Ontario and Newfoundland continues to be negative.

1. Badets, J., 1993, "Canada's Immigrants: Recent Trends," *Canadian Social Trends*, No. 29, Summer, Statistics Canada Catalogue No. 11-008-XPE, Ottawa.
2. Statistics Canada, 1994, *Canada's Changing Immigrant Population*, Catalogue No. 96-311E, Ottawa.
3. Beaujot, R.P., 1988, *The Role of Immigration in Changing Socio-Demographic Structures*, Health and Welfare Canada, Ottawa.

Table 4.1.11
Interprovincial Migrants, January to December 1996

Destination:	Nfld.	P.E.I.	N.S.	N.B.	Que.	Ont.	Man.	Sask.	Alta.	B.C.	Y.T.	N.W.T.	Total emigration
Origin							persons						
Newfoundland	...	273	2 072	745	357	6 434	358	130	3 884	2 147	85	488	16 973
Prince Edward Island	244	...	781	393	90	688	49	26	180	217	7	14	2 689
Nova Scotia	1 267	820	...	2 603	1 101	6 617	601	201	2 464	2 409	108	154	18 345
New Brunswick	552	597	2 477	...	2 110	4 256	313	200	1 716	1 267	--	137	13 625
Quebec	180	100	1 147	2 347	...	24 720	687	322	3 774	5 966	75	150	39 468
Ontario	4 268	756	6 595	4 015	16 399	...	5 011	2 295	14 250	24 583	150	433	78 755
Manitoba	130	59	527	230	477	5 139	...	2 833	5 037	4 385	74	139	19 030
Saskatchewan	31	33	313	124	302	2 400	2 724	...	10 427	3 782	90	183	20 409
Alberta	916	141	1 663	910	1 237	9 578	3 376	8 940	...	23 134	506	857	51 258
British Columbia	828	212	2 323	936	2 488	12 385	2 961	3 875	21 451	...	820	463	48 742
Yukon Territory	24	--	22	15	29	140	35	104	518	971	...	64	1 922
Northwest Territories	153	13	179	44	167	456	277	323	1 459	546	175	...	3 792
Total immigration	8 593	3 004	18 099	12 362	24 757	72 813	16 392	19 249	65 160	69 407	2 090	3 082	315 008
Net migration	**-8 380**	**315**	**-246**	**-1 263**	**-14 711**	**-5 942**	**-2 638**	**-1 160**	**13 902**	**20 665**	**168**	**-710**	...

Note:
These figures are preliminary estimates.
Source:
Statistics Canada, 1998, *Annual Demographic Statistics, 1997*, Catalogue No. 91-213-XPB, Ottawa.

Table 4.1.12
Net Migration by Province and Territory, 1970-1996

Year	Nfld.	P.E.I.	N.S.	N.B.	Que.	Ont.	Man.	Sask.	Alta.	B.C.	Y.T. and N.W.T.	Total[1]
						persons						
1970	-5 950	-29	-3 967	-2 373	-41 156	54 590	-7 707	-28 358	9 898	22 579	2 473	**412 559**
1971	733	-129	-755	1 798	-25 005	18 580	-7 251	-17 986	2 408	25 034	2 573	**405 301**
1972	-189	858	2 845	241	-19 891	8 227	-7 735	-17 296	6 538	24 927	1 475	**375 185**
1973	-2 510	478	2 107	2 841	-14 730	-5 275	-2 200	-13 261	2 698	30 537	-685	**433 993**
1974	-618	1 386	1 576	4 192	-11 852	-22 163	-5 400	-4 835	14 810	22 655	249	**421 336**
1975	915	814	4 454	7 572	-12 340	-25 057	-4 134	6 555	23 463	-2 864	622	**385 327**
1976	-2 732	309	361	1 640	-20 801	-10 508	-3 655	3 819	34 215	-1 490	-1 158	**376 971**
1977	-4 009	614	-1 277	-886	-46 536	8 596	-3 789	384	32 344	15 507	-948	**366 918**
1978	-3 540	25	-109	-1 644	-33 424	415	-9 557	-3 701	31 987	20 698	-1 150	**348 929**
1979	-4 217	-225	-1 840	-2 219	-30 025	-15 317	-13 806	-3 510	39 212	33 241	-1 294	**370 862**
1980	-3 082	-1 082	-2 494	-4 165	-24 283	-34 919	-11 342	-4 382	46 933	40 165	-1 349	**372 167**
1981	-6 238	-783	-2 465	-4 766	-22 549	-19 665	-3 621	-520	40 243	21 565	-1 201	**380 041**
1982	261	-6	1 591	2 183	-28 169	19 614	1 498	1 743	3 961	-2 019	-657	**322 634**
1983	-1 092	799	3 861	2 296	-19 080	32 825	950	2 501	-26 246	4 029	-843	**285 599**
1984	-3 585	524	2 963	812	-10 943	36 691	-49	733	-30 591	3 505	-60	**273 323**
1985	-5 019	-13	-234	-1 559	-6 023	33 414	-1 755	-5 014	-9 568	-3 199	-1 030	**281 275**
1986	-4 682	-493	-739	-2 897	-3 020	42 916	-3 039	-7 020	-20 293	910	-1 643	**302 352**
1987	-4 374	301	-2 183	-1 762	-7 410	40 278	-4 751	-9 043	-27 595	17 618	-1 079	**318 890**
1988	-2 154	424	71	-1 215	-7 003	14 898	-8 584	-16 338	-5 535	25 865	-429	**323 685**
1989	-2 606	-102	572	-21	-8 379	-1 205	-10 004	-18 589	3 366	37 367	-399	**347 990**
1990	-1 137	-273	-106	1 014	-9 567	-15 117	-8 613	-15 928	11 055	38 704	-32	**332 637**
1991	-1 084	-415	1 039	-79	-13 047	-9 978	-7 581	-9 499	5 511	34 572	561	**315 420**
1992	-2 563	232	355	-1 087	-9 785	-13 530	-6 417	-7 727	1 030	39 578	-86	**309 261**
1993	-3 397	532	-1 143	-492	-7 426	-12 771	-5 206	-4 543	-2 355	37 595	-794	**283 297**
1994	-6 204	694	-2 694	-505	-10 252	-4 527	-4 010	-3 958	-2 684	34 449	-309	**286 370**
1995	-6 566	368	-1 972	-931	-10 248	-1 764	-3 344	-3 190	4 251	23 414	-18	**286 259**
1996[2]	-8 380	315	-246	-1 263	-14 711	-5 942	-2 638	-1 160	13 902	20 665	-542	**315 008**
Total	**-84 019**	**5 123**	**-429**	**-3 275**	**-467 655**	**113 306**	**-143 740**	**-180 123**	**202 958**	**565 607**	**-7 753**	**9 233 589**

Notes:
1. Total yearly migratory movement in Canada.
2. These figures are preliminary estimates.
Source:
Statistics Canada, 1998, *Annual Demographic Statistics, 1997*, Catalogue No. 91-213-XPB, Ottawa.

4.1.3 Population projections

Aging

The age structure of the Canadian population has changed over the last 100 years. As Table 4.1.13 indicates, the number of seniors has been increasing, from 271 000 (5% of total population) in 1901 to 3.6 million (12% of total population) in 1996. In 1901, the 5- to 14-year-old age group was the largest: by 1996, the largest group was the 35- to 44-year-olds. The change is explained by a decrease in the fertility rate and an increase in life expectancy at birth (Table 4.1.14).

Table 4.1.13
Population by Age Group, Selected Years

Age group	Population 1901	1951	1996	Change 1901-1951	1951-1996
	thousands			percent	
0 to 4	646	1 722.1	1 965.3	166.6	14.1
5 to 14	1 201	2 528.6	4 026.5	110.5	59.2
15 to 24	1 072	2 146.6	4 023.6	100.2	87.4
25 to 34	799	2 173.9	4 745.9	172.1	118.3
35 to 44	630	1 867.7	5 001.6	196.5	167.8
45 to 54	448	1 407.3	3 787.9	214.1	169.2
55 to 64	304	1 076.8	2 539.1	254.2	135.8
65 and over	271	1 086.3	3 582.0	300.8	229.8
Total	**5 371**	**14 009.0**	**29 672.0**	**160.8**	**111.8**

Sources:
Statistics Canada, 1983, *Historical Statistics of Canada*, Second Edition, F.H. Leacy (ed.), Catalogue No. 11-516E, Ottawa.
Statistics Canada, CANSIM, matrix 6367.

Table 4.1.14
Life Expectancy at Birth by Sex, 1920-22 to 1997

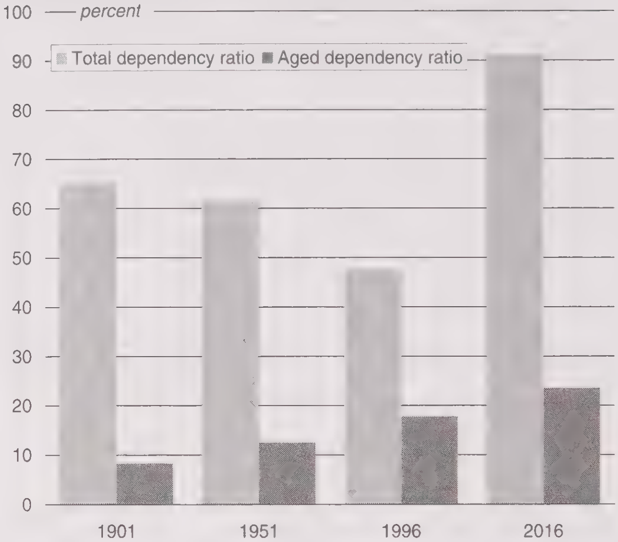
Years	Men	Women
	age in years	
1920 to 1922	58.8	60.6
1925 to 1927	60.5	62.3
1930 to 1932	60.0	62.1
1935 to 1937	61.3	63.7
1940 to 1942	63.0	66.3
1945 to 1947	65.1	68.6
1950 to 1952	66.4	70.9
1955 to 1957	67.7	73.0
1960 to 1962	68.4	74.3
1965 to 1967	68.7	75.3
1970 to 1972	69.4	76.5
1975 to 1977	70.3	77.7
1980 to 1982	71.9	79.1
1985 to 1987	73.0	79.7
1990 to 1992	74.6	80.9
1997	75.8	81.4

Note:
1.These figures are preliminary estimates.
Sources:
Statistics Canada, *Births and Deaths*, Catalogue No. 84-210-XIB, Ottawa.
Statistics Canada, 1998, *Annual Demographic Statistics, 1997*, Catalogue No. 91-213-XPB, Ottawa.

The combination of lower fertility and extended life expectancy results in increased numbers of elderly people. This is reflected in the aged dependency ratio (the population aged over 64 in relation to the population aged 15 to 64), which increased over the course of the century (Figure 4.1.4).

The total dependency ratio (which represents the number of people under 15 and over 64 years of age in relation to the population aged 15 to 64) fell during the 1960s as the baby boomers entered the labour force. The ratio will rise again as the first baby boomers reach 65 years of age, around 2010. The composition of the dependency ratio, however, will be different this time around. Historically, the ratio was high because there were large cohorts of children (Figure 4.1.5: 1901 age pyramid): in the new millennium, the ratio will increase because of large numbers of elderly people (Figure 4.1.5: 2016 age pyramid). This has strong implica-

Figure 4.1.4
Dependency Ratios, Selected Years



Sources:
Statistics Canada, 1983, *Historical Statistics of Canada*, Second Edition, F.H. Leacy (ed.), Catalogue No. 11-516E, Ottawa.
Statistics Canada, 1998, *Annual Demographic Statistics, 1997*, Catalogue No. 91-213-XPB, Ottawa.
Statistics Canada, CANSIM, matrix 6367.

tions for three age-related programs in Canada— health care, education and pensions.[1, 2]

Projections

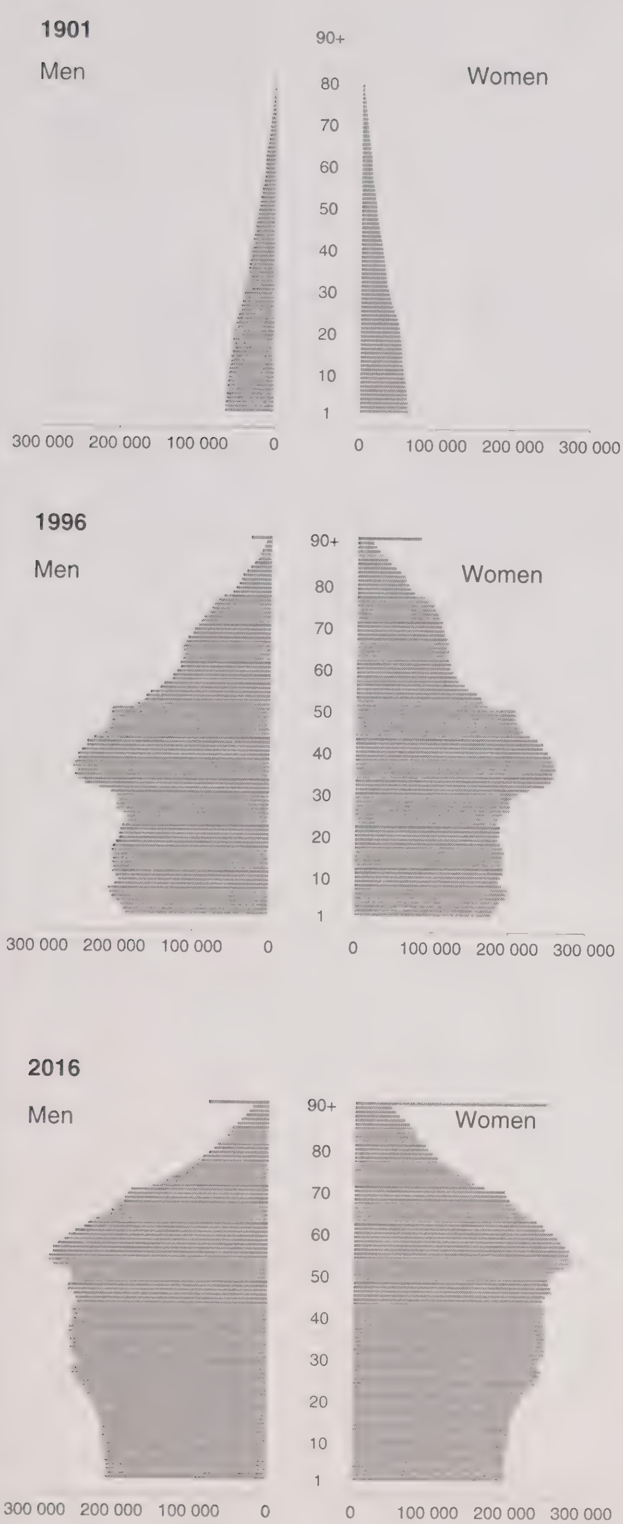
Population projections are models that estimate scenarios of demographic evolution. The components of population growth are analysed, and values are extrapolated and applied to a base population. In these projections, the parameters of each of the population growth components have been estimated up to 2016 and then held constant up to 2041 for the long-term growth perspective. Table 4.1.15 spells out the assumptions underlying the projections that are presented in this section. Figure 4.1.6 shows trend lines for these three demographic projections.

Projection 1, a low-growth scenario, shows that the Canadian population will peak at around 35.5 million in 2030, before slowly receding. Projection 3, a high-growth scenario, demonstrates what effect a higher fertility rate, life expectancy and immigration rate would have on total population: under this projection, the population would not stabilize in the foreseeable future.

Projection 2, a medium-growth scenario, applies the current population growth trend until 2030. The age structure of that projection is shown in the 2016 pyramid in Figure 4.1.5. This

1. Chawla, R., 1991, "Dependency Ratios," *Canadian Social Trends*, No. 20, Spring, Statistics Canada Catalogue No. 11-008-XPE, Ottawa.
2. Fellegi, I., 1988, "Can We Afford an Aging Society?" *Canadian Economic Observer*, October, Statistics Canada Catalogue No. 11-010-XPB, Ottawa.

Figure 4.1.5
Age Pyramid, 1901, 1996 and 2016

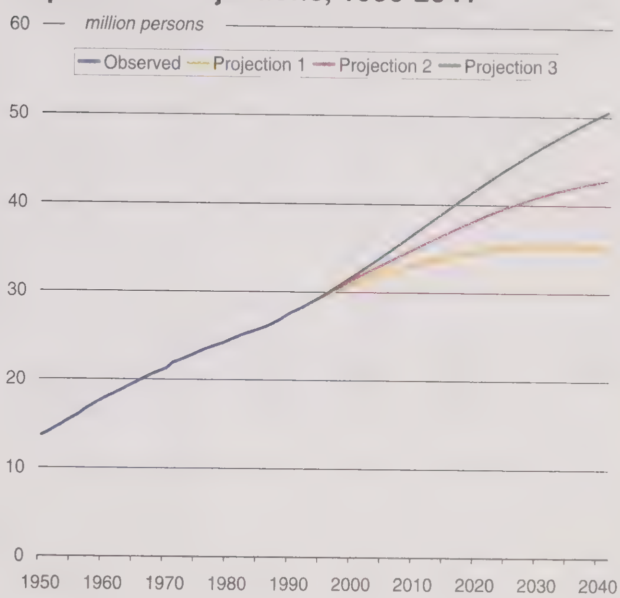


Source:
Statistics Canada, Demography Division.

pyramid offers a top-heavy age structure, indicating an increase in the average age of the population. In this model the fertility rate is set at 1.7 children per woman, life expectancy at 78 years for men and 84 years for women, and immigration level at 250 000 people per year. This projection shows a total population of 37 million by 2016, and 42 million by 2041.

What is common to all three projections is that Canada's population is likely to grow at a slower pace than in the recent past. However, the population growth rates are not evenly distributed across the nation. Assuming projection 2 (Table 4.1.16), Newfoundland and New Brunswick would see their population decline during the period, whereas Ontario would grow at the strongest rate, absorbing 56% of the total increase in the Canadian population.

Figure 4.1.6
Population Projections, 1950-2041



Source:
Statistics Canada, Demography Division.

Text Box 4.1.2
Population Projection Around the World

According to United Nations population projections, world population will increase from 6 billion in 1999 to 8 billion in 2028 and 9 billion in 2054. This increase will occur despite a predicted slowdown in the annual rate of growth, from the current rate of 1.3% to 0.3% in 2050.

Source:
United Nations Population Information Network, *Revision of the World Estimates and Projections*, <http://www.popin.org/pop1998/1.htm>, (accessed October 20, 1999).

Table 4.1.15

Summary of Component Assumptions Underlying Projections 1 to 3, Canada, 1993 to 2016

	Fertility		Mortality		Immigration		Internal	Population
Projection	Scenario	Rate by 2016	Scenario	Life expectancy by 2016	Scenario	Level in 2016	migration	by 2016
		births per woman		years		persons per year		thousand persons
1- Low growth, medium migration	low	1.5	low	men: 77.0 women: 83.1	low	150 000	medium	34 238
2- Medium growth, medium migration	medium	1.7	medium	men: 78.5 women: 84.1	medium	250 000	medium	37 120
3- High growth, west migration	high	1.9	high	men: 81.0 women: 86.1	high	330 000	west	39 883

Note:
The assumptions for emigration, non-permanent residents and returning Canadians are the same for all projection series.
Source:
Statistics Canada, Demography Division

Table 4.1.16

Projected Population by Province and Territory, 1993-2041 (Projection 2, Medium-growth Scenario)

Year	Canada	Nfld.	P.E.I.	N.S.	N.B.	Que.	Ont.	Man.	Sask.	Alta.	B.C.	Y.T.	N.W.T.
							thousands						
1993	28 798	581	132	924	752	7 215	10 766	1 118	1 004	2 670	3 542	32	63
1994	29 183	582	132	928	755	7 282	10 943	1 123	1 004	2 710	3 628	33	64
1995	29 563	582	133	932	757	7 346	11 120	1 127	1 003	2 750	3 712	34	65
1996	29 964	582	134	936	759	7 414	11 314	1 132	1 003	2 789	3 798	35	66
1997	30 358	582	135	940	762	7 479	11 507	1 137	1 004	2 828	3 881	35	68
1998	30 747	581	136	944	764	7 544	11 699	1 142	1 005	2 866	3 962	36	69
1999	31 129	580	137	947	765	7 606	11 891	1 148	1 005	2 903	4 040	36	70
2000	31 506	579	137	950	767	7 668	12 083	1 153	1 006	2 940	4 115	37	71
2001	31 877	577	138	953	768	7 727	12 274	1 159	1 006	2 977	4 187	37	73
2002	32 244	576	139	955	769	7 785	12 464	1 164	1 007	3 015	4 259	38	74
2003	32 607	574	139	958	770	7 841	12 653	1 169	1 008	3 052	4 329	38	75
2004	32 967	571	140	960	770	7 897	12 843	1 175	1 008	3 089	4 398	38	77
2005	33 323	569	141	962	771	7 951	13 032	1 180	1 009	3 127	4 465	39	78
2006	33 677	566	141	964	771	8 004	13 221	1 186	1 010	3 164	4 531	39	80
2007	34 030	563	142	966	771	8 056	13 410	1 191	1 012	3 201	4 597	39	81
2008	34 380	560	142	967	772	8 108	13 599	1 196	1 013	3 238	4 662	40	82
2009	34 728	557	143	969	771	8 159	13 787	1 202	1 014	3 275	4 727	40	84
2010	35 075	554	143	970	771	8 208	13 976	1 207	1 016	3 312	4 791	40	85
2011	35 420	551	144	972	771	8 258	14 165	1 212	1 017	3 349	4 855	40	87
2012	35 764	547	144	973	771	8 306	14 354	1 218	1 019	3 385	4 919	40	88
2013	36 106	544	145	974	771	8 353	14 542	1 223	1 020	3 421	4 983	41	90
2014	36 446	541	145	974	771	8 400	14 731	1 228	1 022	3 457	5 046	41	91
2015	36 784	537	145	975	770	8 446	14 919	1 234	1 023	3 493	5 109	41	93
2016	37 120	533	146	976	770	8 491	15 107	1 239	1 025	3 527	5 171	41	94
2017	37 449	530	146	976	770	8 535	15 293	1 244	1 026	3 561	5 233	41	95
2018	37 773	526	146	976	769	8 577	15 476	1 249	1 027	3 595	5 293	41	97
2019	38 089	522	147	976	769	8 617	15 656	1 254	1 028	3 627	5 353	41	98
2020	38 398	519	147	976	768	8 656	15 833	1 259	1 030	3 659	5 411	42	99
2021	38 699	515	147	976	767	8 692	16 006	1 263	1 031	3 690	5 468	42	101
2022	38 992	512	148	976	767	8 727	16 176	1 268	1 032	3 720	5 524	42	102
2023	39 277	508	148	976	766	8 759	16 342	1 272	1 033	3 749	5 579	42	103
2024	39 552	505	148	975	765	8 790	16 504	1 276	1 034	3 777	5 632	42	104
2025	39 818	502	148	975	764	8 818	16 662	1 280	1 035	3 804	5 684	42	105
2026	40 075	498	148	974	763	8 844	16 816	1 283	1 035	3 830	5 735	42	106
2027	40 322	495	148	973	761	8 867	16 965	1 287	1 036	3 856	5 784	42	107
2028	40 560	491	149	972	760	8 889	17 110	1 290	1 037	3 880	5 831	43	108
2029	40 788	488	149	971	759	8 908	17 251	1 293	1 037	3 904	5 878	43	109
2030	41 007	485	149	970	757	8 926	17 387	1 295	1 038	3 926	5 922	43	109
2031	41 216	481	149	968	755	8 942	17 519	1 298	1 038	3 948	5 965	43	110
2032	41 416	478	149	966	753	8 955	17 647	1 300	1 039	3 968	6 007	43	111
2033	41 607	474	149	965	751	8 967	17 770	1 302	1 039	3 988	6 047	43	112
2034	41 790	471	148	963	749	8 977	17 889	1 304	1 039	4 007	6 086	43	113
2035	41 964	467	148	961	747	8 986	18 004	1 306	1 039	4 025	6 124	43	113
2036	42 130	464	148	958	745	8 993	18 115	1 308	1 039	4 043	6 160	43	114
2037	42 288	460	148	956	742	8 999	18 223	1 309	1 039	4 059	6 194	44	115
2038	42 439	457	148	954	740	9 004	18 327	1 311	1 038	4 075	6 228	44	115
2039	42 584	453	148	951	737	9 007	18 427	1 312	1 038	4 090	6 260	44	116
2040	42 721	450	147	949	735	9 010	18 524	1 313	1 038	4 104	6 291	44	116
2041	42 852	447	147	946	732	9 011	18 618	1 314	1 037	4 118	6 321	44	117

Source:
Statistics Canada, Demography Division.

4.2 Economy

Human beings have always drawn their means of subsistence from the environment. The resulting economic activity has intensified not only because of population increase, but also because of the constant effort of trying to improve the standard of living. This section examines specific issues that pertain to the economic activities of Canadians, especially those activities that, when combined with demographic forces, may significantly alter environmental resources.

4.2.1 Gross Domestic Product

Gross Domestic Product (GDP, Text Box 4.2.1) has grown throughout the 20th century (Figure 4.2.1). However, the rate of growth of GDP has been generally slowing down since the 1972 energy crisis. Average growth rates for both GDP and GDP per capita have also been declining, as have population growth rates (Figure 4.2.2; see also sub-section 4.1.1–**Population distribution and density**). During the 1960s, per capita income was increasing 3.4% each year on average, whereas in the 1990s the annual average increase was only about 1%.

The composition of output changed markedly between 1961 and 1996. Table 4.2.1 shows a general shift from resource-based[1] industries to service industries, although there are notable exceptions. For instance, the resource-based fuel and energy industries have gained in relative importance whereas the transportation and communication industries, along with the retail and wholesale trade industries, have declined. Personal and business service industries increased from 12.6% of GDP in 1961 to 21.1% in 1996. This shift resulted from a number of long-term trends, such as the higher participation rate of women in the labour force and more contracting out of services by business.

Text Box 4.2.1

Gross Domestic Product

Gross Domestic Product, or GDP, is the measure of the value of the goods and services produced by the capital and labour employed in Canada in a given period. Therefore, GDP is equal to the value of their remuneration (wages, salaries, profits, interest payments and depreciation). Because of accounting identities, GDP is also equal to the value of final sales minus imports. To avoid double counting, the sales of products used in the production of other products are excluded. Thus the GDP of an industry is the value of its output minus the purchases of goods and services used in the production process.

The use of GDP as a measure of well-being is misleading; it accounts for production of remunerated capital and labour only, and not for unpaid work or services from natural resources or the environment.

1. Resource-based industries in this section regroup the extraction and downstream manufacturing industries. For further detail, see sections 4.4–**Agriculture**, 4.5–**Fisheries**, 4.6–**Forest industries**, and 4.7–**Mineral industries**.

Table 4.2.1

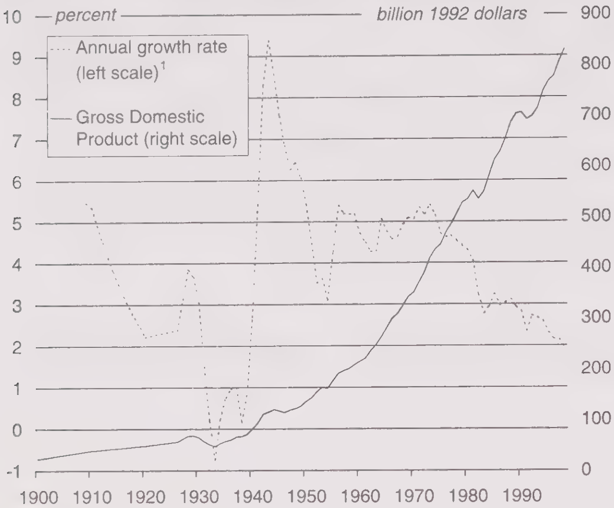
Gross Domestic Product by Industry, Selected Years

Industry[1]	1961	1966	1971	1976	1981	1986	1991	1996
				percent of total output				
Agricultural products[2]	8.5	9.0	6.5	6.4	5.7	5.4	4.7	4.5
Forest products[2]	6.2	5.6	4.7	4.8	4.5	4.5	3.6	4.9
Mineral products[2]	7.5	7.6	6.4	5.6	5.2	4.4	3.6	3.9
Fuel and energy	4.7	4.3	4.7	6.4	8.0	7.2	6.3	6.9
Chemical products	2.1	2.3	2.0	1.8	2.1	2.1	2.1	2.5
Textiles, fabrics and clothing	2.3	2.1	1.8	1.5	1.3	1.2	0.9	0.8
Electrical products	1.6	1.8	1.6	1.3	1.3	1.2	1.1	1.1
Machinery and equipment	1.5	1.8	1.4	1.3	1.5	1.3	1.1	1.3
Transportation equipment	1.9	2.4	2.6	2.2	1.8	2.4	2.2	3.3
Miscellaneous goods	0.7	0.7	0.6	0.6	0.6	0.5	0.4	0.6
Construction	7.6	7.7	7.4	8.4	7.8	6.1	6.4	5.0
Transportation and communication	9.2	8.8	8.7	8.1	8.2	8.2	7.5	7.4
Retail and wholesale trade	12.3	11.7	11.9	11.7	10.8	11.6	11.4	10.7
Finance and insurance	7.5	7.0	7.6	7.4	7.6	8.3	8.9	8.5
Real estate	4.8	4.3	4.8	4.3	5.1	6.0	7.0	7.3
Personal service	10.7	11.5	13.5	13.8	13.8	14.4	16.0	15.5
Government service	9.0	9.2	10.9	11.4	10.7	11.0	11.8	10.2
Business service	1.9	2.2	2.8	3.2	4.0	4.2	5.0	5.6
Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Notes:
1. The industry classification in this table is a special aggregation based on the 1980 Standard Industrial Classification (SIC).
2. Includes both extraction and downstream manufacturing industries.

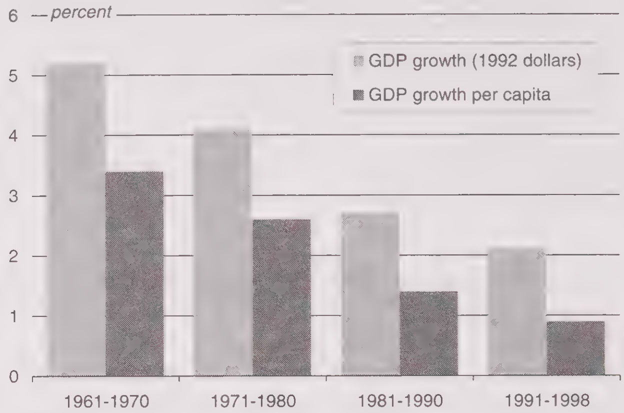
Sources:
Statistics Canada, Input-Output Division, and Environment Accounts and Statistics Division.

Figure 4.2.1
Gross Domestic Product, 1900-1998



Notes:
The series for different periods were linked on ratios of overlapping years. Data prior to 1925 were available for selected years; missing years were interpolated.
1. Ten-year moving average trendline.
Sources:
Firestone, O.J., 1958, "Canada's Economic Development," in *Income and Wealth Series VII*, Bowes and Bowes, London.
Statistics Canada, 1983, *Historical Statistics of Canada, Second Edition*, F.H. Leacy (ed.), Catalogue No. 11-516E, Ottawa.
Statistics Canada, Income and Expenditure Accounts Division.

Figure 4.2.2
Average Growth Rates of Gross Domestic Product and Gross Domestic Product per Capita, Selected Years



Sources:
Statistics Canada, Input-Output Division, and Environment Accounts and Statistics Division.

4.2.2 Employment

Employment shares by industry generally follow the patterns identified in the analysis of GDP by industry. Table 4.2.2 shows a significant decline in employment in the agricultural products industries, from 14.1% of total employment in 1961 to 5.5% in 1996. In contrast, the share of employment in the service industries rose from 63.6% in 1961 to 79.8% in 1996.

The largest increases of employment shares occurred in the business service and personal service industries. These industries gained five more percentage points in employment share than in GDP share over the period 1961 to 1996, indicating a relative decrease in income per employee. The government sector was the largest employer from 1961 to 1996.

Table 4.2.2
Employment by Industry, Selected Years

Industry[1]	1961	1966	1971	1976	1981	1986	1991	1996
				percent				
Agricultural products[2]	14.1	10.8	9.0	7.0	7.1	6.5	5.7	5.5
Forest products[2]	5.5	5.2	4.7	4.4	4.1	3.8	3.4	3.5
Mineral products[2]	5.1	5.4	4.9	4.5	4.0	3.3	2.9	2.8
Fuel and energy	1.1	1.0	1.1	1.1	1.3	1.3	1.3	1.2
Chemical products	1.6	1.6	1.6	1.6	1.5	1.5	1.4	1.4
Textiles, fabrics and clothing	3.6	3.3	2.8	2.5	2.0	1.8	1.4	1.2
Electrical products	1.5	1.7	1.6	1.4	1.3	1.1	1.0	0.8
Machinery and equipment	1.3	1.6	1.4	1.4	1.5	1.3	1.1	1.3
Transportation equipment	1.7	2.1	2.0	1.9	1.9	2.0	1.7	1.9
Miscellaneous goods	0.9	0.9	0.9	0.9	0.8	0.8	0.7	0.7
Construction	8.6	9.0	7.8	8.3	6.9	6.2	6.4	5.9
Transportation and communication	7.1	6.9	6.3	6.2	6.2	5.9	5.7	5.9
Retail and wholesale trade	15.4	15.5	16.3	16.6	17.0	17.8	17.4	17.4
Finance and insurance	3.4	3.6	4.1	4.6	5.0	5.2	5.6	5.3
Real estate	...	...	...	...	...	...	...	...
Personal service	11.0	12.0	12.2	13.0	14.6	16.4	17.5	18.6
Government service	16.5	17.3	20.5	21.1	20.1	20.1	20.8	19.4
Business service	1.6	2.2	2.8	3.5	4.6	5.2	6.1	7.3
Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Notes:
1. The industry classification in this table is a special aggregation based on the 1980 Standard Industrial Classification (SIC).
2. Includes both extraction and downstream manufacturing industries.
Sources:
Statistics Canada, Input-Output Division, and Environment Accounts and Statistics Division.

Table 4.2.3
Consumer Expenditures, Selected Years

Expenditure	1961	1966	1971	1976	1981	1986	1991	1996	1998
	percent of total consumer expenditures on goods and services								
Food, beverages and tobacco									
Food and non-alcoholic beverages	19.1	17.7	15.0	14.0	13.7	12.0	10.9	10.1	9.7
Alcoholic beverages bought in stores	2.9	2.9	3.1	2.8	2.7	2.6	2.2	2.0	2.0
Tobacco products	3.1	2.8	2.7	2.0	2.0	2.2	2.6	1.7	1.8
Total	**25.1**	**23.5**	**20.8**	**18.8**	**18.3**	**16.8**	**15.7**	**13.9**	**13.5**
Clothing and footwear									
Men's and boys' clothing	3.0	3.0	2.9	2.6	2.3	2.2	1.8	1.7	1.7
Women's, girls' and children's clothing	4.1	4.0	3.9	3.6	3.3	3.1	2.8	2.5	2.6
Footwear	1.6	1.4	1.2	1.1	1.1	0.9	0.8	0.7	0.7
Total	**8.7**	**8.4**	**8.0**	**7.4**	**6.7**	**6.2**	**5.4**	**4.9**	**5.0**
Gross rent, fuel and power									
Gross imputed rent services	10.0	9.6	10.9	10.4	11.9	12.7	14.1	14.9	14.4
Gross paid rent services	4.3	4.4	5.3	4.5	4.6	4.8	5.3	5.3	5.1
Other shelter expenses	0.7	0.7	0.7	0.7	0.7	0.8	0.8	0.8	0.8
Electricity	1.3	1.2	1.4	1.5	1.8	2.0	2.3	2.3	2.1
Natural gas	0.5	0.6	0.5	0.6	0.8	0.8	0.7	0.8	0.7
Other fuels	2.1	1.5	1.4	1.4	1.3	0.8	0.6	0.5	0.4
Total	**18.9**	**18.1**	**20.2**	**19.1**	**21.1**	**21.9**	**23.8**	**24.5**	**23.5**
Furniture, furnishings and household equipment and maintenance									
Furniture, carpets and other floor coverings	1.7	1.9	1.8	2.1	1.8	1.6	1.3	1.1	1.1
Household appliances	1.6	1.6	1.5	1.8	1.5	1.6	1.3	1.2	1.3
Semi-durable household furnishings	2.8	2.7	2.7	3.1	3.0	2.7	2.4	2.4	2.4
Non-durable household supplies	1.6	1.6	1.9	2.1	2.1	2.0	1.9	1.8	1.8
Domestic and child care services	1.2	1.0	0.8	0.7	0.8	1.0	1.1	1.2	1.1
Other household services	0.8	0.8	0.7	0.6	0.6	0.6	0.6	0.6	0.6
Total	**9.8**	**9.6**	**9.4**	**10.4**	**9.8**	**9.4**	**8.6**	**8.2**	**8.3**
Medical care and health services									
Medical care services	2.4	2.6	1.3	1.5	1.7	1.8	1.9	2.0	1.9
Hospital care services	0.3	0.3	0.2	0.2	0.2	0.3	0.3	0.2	0.2
Other medical care service expenses	0.2	0.2	0.2	0.3	0.4	0.4	0.5	0.7	0.7
Drugs and pharmaceutical products	1.1	1.1	1.3	1.1	1.1	1.2	1.4	1.5	1.4
Total	**4.1**	**4.3**	**3.0**	**3.1**	**3.3**	**3.8**	**4.0**	**4.4**	**4.2**
Transportation and communications									
New and used motor vehicles	5.1	6.3	5.4	5.5	4.7	6.0	4.9	5.5	6.5
Motor vehicle repairs and parts	1.8	1.8	1.9	2.1	2.3	2.1	2.1	2.0	1.9
Motor fuels and lubricants	2.7	2.8	3.0	3.2	4.0	3.4	3.2	3.0	2.7
Other auto-related services	0.9	1.0	1.2	1.2	1.0	1.2	1.4	1.5	1.5
Purchased transportation services	1.7	1.7	1.8	1.9	2.2	2.1	2.0	2.1	2.2
Communication services	1.4	1.5	1.6	1.6	1.7	1.7	1.7	1.7	1.9
Total	**13.7**	**15.1**	**15.0**	**15.5**	**16.0**	**16.5**	**15.3**	**15.9**	**16.6**
Recreational, entertainment, education and cultural services									
Recreational, sporting and camping equipment	2.1	2.5	3.3	3.8	3.6	3.7	3.5	3.5	3.6
Reading and entertainment supplies	1.7	1.7	1.8	1.8	1.8	1.7	1.7	1.6	1.7
Recreational services	1.0	1.2	1.7	2.2	2.2	2.6	2.9	3.7	3.9
Education and cultural services	0.7	1.2	1.0	0.8	0.8	1.0	1.0	1.2	1.2
Total	**5.5**	**6.5**	**7.7**	**8.6**	**8.3**	**9.0**	**9.0**	**10.0**	**10.4**
Miscellaneous goods and services									
Personal effects	0.7	0.7	0.6	1.0	0.9	0.8	0.7	0.6	0.6
Personal care services	1.8	2.0	1.9	1.6	1.7	1.9	2.0	2.0	2.0
Restaurants and accommodation services	6.4	6.6	7.1	7.8	7.6	7.1	7.0	7.0	7.1
Financial and legal services	3.9	4.1	4.8	4.5	4.5	4.9	5.3	6.4	7.1
Operating expenses of non-profit service organizations	1.0	1.1	1.2	1.4	1.5	1.7	2.0	2.0	1.9
Total	**13.8**	**14.4**	**15.7**	**16.3**	**16.2**	**16.5**	**16.8**	**18.1**	**18.7**
Net expenditure abroad	0.5	-	0.2	0.8	0.2	-	1.3	0.2	-0.3
Total	**0.5**	**-**	**0.2**	**0.8**	**0.2**	**-**	**1.3**	**0.2**	**-0.3**
Total consumer expenditures on goods and services	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**
Total services	**38.2**	**39.3**	**41.7**	**41.2**	**43.4**	**45.9**	**49.0**	**52.5**	**52.8**

Source:
Statistics Canada, *National Income and Expenditure Accounts, Quarterly Estimates*, Catalogue No. 13-001-XPB, Ottawa.

4.2.3 Consumer expenditures

Consumer expenditures are the largest component of GDP, representing almost 60% in 1998. Consumer expenditures per capita more than doubled between 1961 and 1998, from $7 300 to almost $16 000 (Figure 4.2.3).

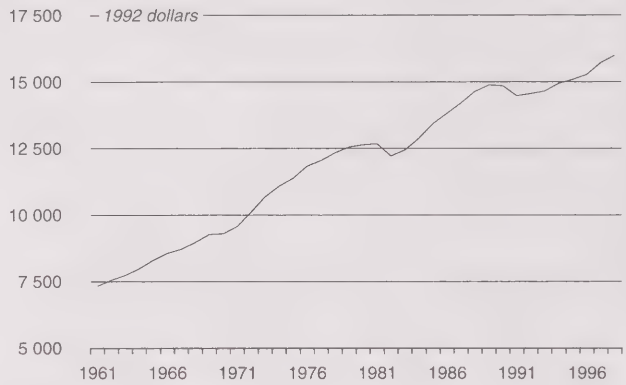
The largest single variation of consumer expenditures over the last 35 years is the decline of food and non-alcoholic beverage expenditures. These expenditures decreased from 19.1% to 9.7% of total consumer expenditures between 1961 and 1998 (Table 4.2.3).[1] More generally, the share of consumer expenditures for food, beverages and tobacco and for clothing and footwear declined from 33.8% in 1961 to 18.5% in 1998.

The share of consumer expenditures made on services increased from 38.2% of total consumer expenditures in 1961 to 52.8% in 1998. Recreational services as well as financial and legal services have seen the greatest increase in expenditures.

Services, in general, have less impact on the environment. However, some services, such as transportation, have important environmental impacts (see Text Box 4.8.1 in section 4.8–**Transportation**). The share of consumer expenditures on transportation has remained stable, except for the increase in the amount spent on motor vehicles.

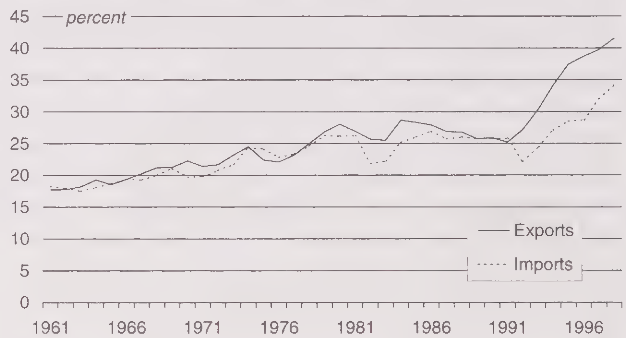
The share spent on recreational, sporting and camping equipment and on recreational services rose from 3.1% in 1961 to 7.5% in 1998. Recreation covers a broad range of activities that can have diverse effects on the environment. For example, the urban environment can benefit from activities that rely less on the use of automobiles. In contrast, natural habitats in remote areas are increasingly threatened by the greater mobility afforded by new types of recreational vehicles.

Figure 4.2.3
Consumer Expenditures per Capita, 1961-1998



Source:
Statistics Canada, Input-Output Division.

Figure 4.2.4
International Trade as a Share of Gross Domestic Product, 1961-1998



Source:
Statistics Canada, Input-Output Division.

4.2.4 International trade

Canada's economy is increasingly open to international trade. The value of exports as a share of GDP more than doubled from 17.7% in 1961 to 41.5% in 1998; the value of imports also increased, from 18.2% of GDP to 34.2% (Figure 4.2.4).

In 1961, resource-based industries dominated Canada's exports, representing two-thirds of goods and services sent abroad (Table 4.2.4). However, by 1995, these industries represented about one-third of the value of exports. The largest increase in the value of both exports and imports occurred in the trade of transportation equipment between 1961 and 1971, and it is explained by the implementation of the Canada–United States Auto Pact. In 1995, transportation equipment was still the largest contributor to Canadian international trade, representing 23.6% of exports and 21.0% of imports. Cars, trucks and other motor vehicles accounted for 17.3% of Canadian exports in 1998.[2]

Table 4.2.5, which shows exports and imports in relation to total production and total domestic demand, demonstrates the increasing reliance of the Canadian economy on international trade. Between 1961 and 1995, every single industry class increased its exports. On the import side, all industry classes, with the exception of only the fuel and energy industries, increased their trade figures.

1. The shares reflect current prices.

2. Statistics Canada, CANSIM, matrix 3685.

Table 4.2.4
Composition of Exports and Imports, Selected Years

Industry[1]	Exports 1961	Exports 1971	Exports 1981	Exports 1991	Exports 1995	Imports 1961	Imports 1971	Imports 1981	Imports 1991	Imports 1995
	percent of total exports					percent of total imports				
Agricultural products[2]	17.0	10.2	10.7	7.1	6.6	12.5	8.0	7.2	6.5	5.7
Forest products[2]	21.3	13.6	12.5	11.0	12.8	4.0	3.3	2.9	3.7	3.9
Mineral products[2]	24.3	17.8	17.6	13.3	11.3	12.2	10.3	12.0	8.4	9.3
Fuel and energy[2]	3.7	6.2	10.5	7.6	6.2	7.9	5.9	10.9	4.3	3.1
Chemical products	3.1	2.1	3.5	4.7	5.4	5.9	5.9	6.0	7.5	8.6
Textiles, fabrics and clothing	1.0	0.9	1.0	1.2	1.6	6.5	5.5	4.3	4.9	4.5
Electrical products	1.1	2.3	2.5	4.5	4.9	5.6	5.6	6.3	9.3	10.0
Machinery and equipment	3.1	4.6	6.1	6.3	7.2	14.2	15.6	15.4	13.8	15.9
Transportation equipment	2.8	21.4	17.1	21.9	23.6	11.7	21.9	20.0	21.3	21.2
Miscellaneous goods	0.3	0.7	1.5	1.7	2.1	2.4	2.0	2.6	3.4	3.1
Construction	-	-	-	-	-	-	-	-	-	-
Transportation and communication	9.2	7.6	8.0	7.9	6.5	1.7	1.3	2.5	3.3	3.0
Retail and wholesale trade	1.8	2.7	2.4	3.4	3.3	0.1	0.4	0.2	0.2	0.2
Finance and insurance	0.9	0.8	1.2	2.3	2.2	1.3	1.9	1.9	3.4	3.2
Real estate	-	-	0.1	0.1	0.1	-	-	-	-	-
Personal service	0.3	0.5	2.5	3.3	2.5	0.4	0.9	3.4	4.9	3.5
Government service	-	-	-	-	-	-	-	-	-	-
Business service	0.7	0.9	1.6	2.4	2.5	1.6	1.8	2.9	3.0	3.2
Unallocated imports and exports	9.4	7.8	1.3	1.2	1.2	11.9	9.8	1.6	1.9	1.6
Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Notes:
For statistical reasons, it was impossible to allocate up to 10% of total exports and imports to the appropriate categories prior to 1981. The table therefore underestimates the trade in certain commodities before 1981.
1. The industry classification in this table is a special aggregation based on the 1980 Standard Industrial Classification (SIC).
2. Includes both extraction and downstream manufacturing industries.
Sources:
Statistics Canada, Input-Output Division, and Environment Accounts and Statistics Division.

Table 4.2.5
Export and Import Propensities, Selected Years

Industry[1]	Exports 1961	Exports 1971	Exports 1981	Exports 1991	Exports 1995	Imports 1961	Imports 1971	Imports 1981	Imports 1991	Imports 1995
	percent of production					percent of domestic demand				
Agricultural products[2]	14.0	13.6	17.3	15.8	21.5	11.7	10.6	12.7	15.3	17.9
Forest products[2]	31.4	30.3	33.4	33.9	44.2	8.5	9.1	10.8	15.4	18.2
Mineral products[2]	31.0	29.2	36.7	41.2	44.9	20.0	18.8	28.9	31.5	38.5
Fuel and energy[2]	8.8	18.7	19.6	19.7	24.0	18.3	17.4	20.5	12.7	12.7
Chemical products	12.2	11.2	17.2	27.3	40.6	22.7	25.9	26.4	38.6	50.0
Textiles, fabrics and clothing	3.3	4.9	8.3	15.1	30.1	19.6	22.6	27.5	42.7	52.0
Electrical products	6.7	16.1	24.1	44.5	66.9	29.1	30.8	44.6	63.5	79.2
Machinery and equipment	25.3	40.4	55.8	75.4	88.8	63.0	69.0	76.5	87.5	94.2
Transportation equipment	11.2	62.5	70.4	77.0	82.0	36.7	62.3	73.9	77.3	79.2
Miscellaneous goods	3.6	10.3	28.1	38.3	64.7	24.0	24.7	41.4	57.2	71.4
Construction	-	-	-	-	-	-	-	-	-	-
Transportation and communication	10.4	11.1	14.7	15.3	18.1	2.3	2.1	5.3	7.4	8.7
Retail and wholesale trade	2.2	4.1	4.6	5.9	8.5	0.2	0.7	0.4	0.4	0.6
Finance and insurance	2.5	2.7	4.4	6.6	8.7	4.0	5.7	6.9	9.7	11.6
Real estate	-	-	0.2	0.2	0.2	-	-	0.1	0.1	0.1
Personal service	0.3	0.8	4.6	5.0	5.5	0.6	1.3	6.3	7.5	7.0
Government service	-	-	-	-	-	-	-	-	-	-
Business service	1.2	1.7	3.5	4.3	5.9	3.0	3.4	6.3	5.6	6.9

Notes:
For statistical reasons, it was impossible to allocate up to 10% of total exports and imports to the appropriate categories prior to 1981. The table therefore underestimates the trade in certain commodities before 1981.
1. The industry classification in this table is a special aggregation based on the 1980 Standard Industrial Classification (SIC).
2. Includes both extraction and downstream manufacturing industries.
Sources:
Statistics Canada, Input-Output Division, and Environment Accounts and Statistics Division.

4.3 Science and technology

Over the past 100 years, Canada's economic structure has been dominated in turn by natural resources, manufacturing and services. Scientific discoveries and technological innovations play an important role in driving these economic transitions and have had a tremendous impact on our standard of living, leading to more new discoveries, new demands and new environmental impacts. Advancements in science and technology occur primarily through research and development (Text Box 4.3.1).

Text Box 4.3.1
Defining Science and Technology

Science is the generation of new knowledge. Technology is the application of knowledge. Science and technology (S&T) activities include research and development, S&T education and training, and scientific and technical services.

Research and development is creative work that is undertaken on a systematic basis to increase the stock of new knowledge.

Source:
Organisation for Economic Co-operation and Development (OECD), 1994, *Proposed Standard Practice for Surveys of Research and Experimental Development: Frascati Manual 1993*, Paris.

4.3.1 Research and development

The analysis of investment in research and development (R&D) is one way to monitor the commitment to develop science and technology. Investment in R&D is measured by gross expenditure in research and development (GERD). In 1998, GERD reached $13.9 billion, or approximately 1.5% of Gross Domestic Product (GDP) (Figure 4.3.1). Canada's GERD as a share of GDP ranks among the lower half of all Organisation of Economic Co-operation and Development (OECD) countries (Figure 4.3.2).

Industrial sector

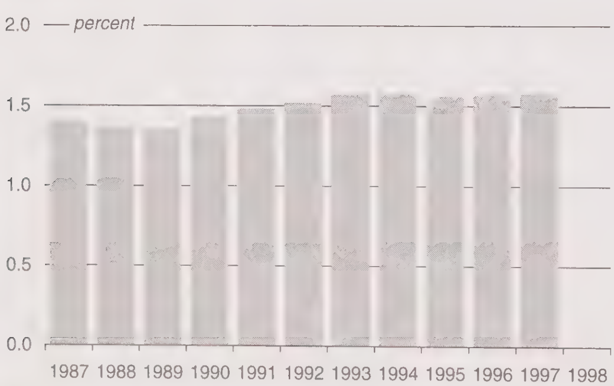
Most of Canada's R&D is conducted by industry[1] and this trend is increasing (Figure 4.3.3). Industry accounted for more than 55% of R&D expenditures in 1987, with the remainder split between government and higher education. By 1998, industry's share of R&D had increased to over 64%.

Canadian industries spent $8.6 billion on R&D in 1997, led by the manufacturing sector (Table 4.3.1). Three manufacturing industries accounted for more than half of R&D expenditures: Telecommunication Equipment; Aircraft and Aircraft Parts; and Pharmaceutical and Medicine. The dominant R&D service industries were Architectural Engineering and Other Scientific and Technical Services, and Computer and Related Services.

Expenditures for R&D in environmental protection totalled 2.2% of all industrial R&D in 1995–96. This proportion remained unchanged from 1990 to 1995 (see section 7.4–**Environmental practices**).

1. Includes private business and private not-for-profit organizations.

Figure 4.3.1
Gross Expenditure in R&D as a Share of GDP, 1987-1997

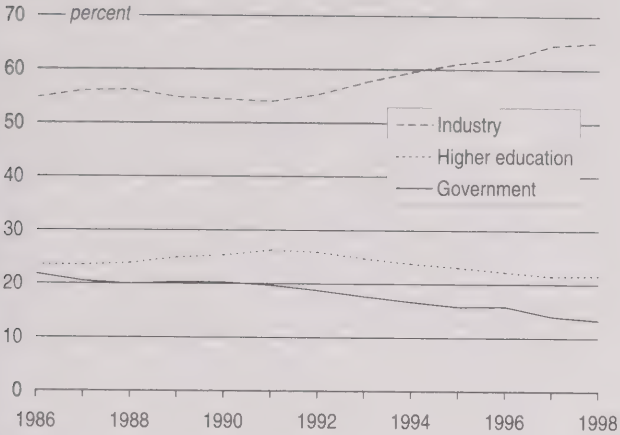


Source:
Statistics Canada, 1998, *Science Statistics*, Vol. 22, No. 5, Catalogue No. 88-001-XIB, Ottawa.

Figure 4.3.2
Gross Expenditure in R&D as a Share of GDP for Selected OECD Countries, 1997

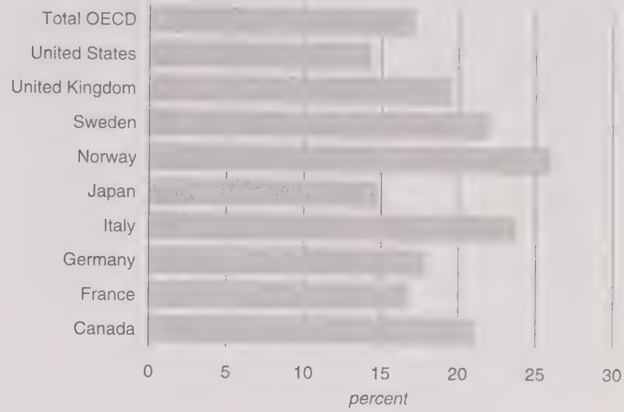
Note:
Figures for France, Japan and the United Kingdom are for 1996. Figures for Norway and Sweden are for 1995.
Source:
Organisation for Economic Co-operation and Development (OECD), 1998, *Main Science and Technology Indicators*, Paris.

Figure 4.3.3
Composition of Gross Expenditure in R&D by Sector, 1986-1998



Source:
Statistics Canada, 1998, *Science Statistics*, Vol. 22, No. 5, Catalogue No. 88-001-XIB, Ottawa.

Figure 4.3.4
Share of Gross Expenditures in R&D by Higher Education Sector for Selected OECD Countries, 1997



Note:
Figures for France, Japan and the United Kingdom are for 1996. Figures for Norway and Sweden are for 1995.
Source:
Organisation for Economic Co-operation and Development (OECD), 1998, *Main Science and Technology Indicators*, Paris, France.

Government sector

Since the early 1990s, the government's share of direct expenditures on R&D has been declining (Figure 4.3.3). Federal and provincial/territorial government organizations accounted for 13.4% of R&D expenditures in 1998. The federal government spent $1.6 billion on its own R&D activities and $1.4 billion on funding R&D in the higher education and industrial sectors.

Federal R&D expenditures are classified according to socio-economic objectives. In 1998–99, the largest items were agriculture, the production, distribution and rational utilization of energy, and the exploration and exploitation of the earth (Table 4.3.2). Direct expenditures on preventing pollution and protecting the environment declined by $14 million between 1995–96 and 1998–99, but this decline is proportional to the overall decrease in government R&D expenditures.[1]

Table 4.3.1
R&D Expenditures by Selected Industry, 1993-1997

Industry	1993	1994	1995	1996	1997
	million dollars				
Agriculture, Fishing, and Logging	45	47	52	57	55
Mining, Quarrying and Oil Wells	166	176	195	185	185
Manufacturing					
Aircraft and Aircraft Parts	670	601	742	845	887
Telecommunication Equipment	906	1 110	1 379	1 474	1 573
Pharmaceutical and Medicine	362	395	462	492	546
Other Manufacturing	2 089	2 170	2 134	2 140	2 246
Construction	14	18	19	19	19
Utilities	231	223	203	240	223
Service					
Wholesale trade	291	266	208	178	180
Computer and Related Services	318	430	464	519	587
Architectural, Engineering and Other Scientific and Technical Services	556	637	676	749	830
Other Service	893	1 047	1 124	1 244	1 296
Total	**6 541**	**7 120**	**7 658**	**8 142**	**8 627**

Source:
Statistics Canada, 1997, *Industrial Research and Development*, Catalogue No. 88-202-XPB, Ottawa.

Higher education sector

Universities contribute a larger share of R&D expenditures in Canada compared with most other OECD countries (Figure 4.3.4). However, the relative contribution of universities to GERD has also been declining since the early 1990s (Figure 4.3.3).

Expenditure and source of funding in R&D in the higher education sector vary by field of study (Table 4.3.3). Social sciences and humanities receive the smallest share and are largely funded by the universities themselves. Other natural sciences and engineering receive the largest share of funding, and the federal government is the single largest contributor.

4.3.2 Publications and inventions

The evolution of science and technology (S&T) depends on the sharing of new knowledge; this, in turn, leads to new discoveries and inventions. Statistics on scientific publications and inventions are important indicators of the state of S&T.

1. Statistics Canada, 1998, *Science Statistics*, Vol. 22, No. 5, Catalogue No. 88-001-XIB, Ottawa.

Table 4.3.2
Federal Government R&D Expenditures by Socio-economic Objective, 1995-96 to 1998-99

Socio-economic objective	1995-96	1996-97	1997-98[1]	1998-99[2]
	million dollars			
Exploration and exploitation of the earth	161	186	167	158
Infrastructure and general planning of land use				
Transport	8	10	10	9
Telecommunications	64	34	28	26
Other	16	74	74	76
Pollution prevention and protection of the environment	99	96	89	85
Public health	37	76	79	74
Production, distribution and rational utilization of energy	201	273	202	169
Agricultural production and technology				
Agriculture	288	320	285	300
Fishing	51	37	29	28
Forestry	75	71	63	59
Industrial production and technology	64	104	102	101
Social structures and relationships	44	102	111	116
Exploration and exploitation of space	62	65	62	86
Non-oriented research	21	47	53	54
Other civil research	3	13	12	13
Defence	115	124	116	115
Other	289	4	4	3
Total R&D expenditures	**1 598**	**1 636**	**1 486**	**1 472**

Notes:
Non-program (indirect) costs are excluded.
1. Data for 1997-98 are preliminary.
2. Data for 1998-99 are estimated.
Source:
Statistics Canada, 1998, *Science Statistics*, Vol. 22, No. 2, Catalogue No. 88-001-XIB, Ottawa.

Table 4.3.3
R&D Expenditures and Source of Funds in the Higher Education Sector, 1996-97

			Source of funds					
Education sector	Total expenditures	Share of total	Federal government	Provincial governments	Business[1]	Higher education	Foreign	Total
	million dollars	percent						
Social sciences and humanities	742.7	25.9	13.9	8.8	-	68.0	-	90.7
Health sciences	963.9	33.6	27.0	9.5	-	27.6	2.3	66.3
Other natural sciences and engineering	1 161.7	40.5	39.7	14.5	-	21.8	1.3	77.3
Total	**2 868.3**	**100.0**	**28.8**	**11.4**	**22.9**	**35.7**	**1.3**	**100.0**

Note:
1. Includes private business and private not-for-profit organizations.
Source:
Statistics Canada, 1998, *Estimation of research and development expenditures in the higher education sector, 1996-1997*, Catalogue No. 88-001-XIB, Vol. 22, No. 7, Ottawa.

Publications

Science and technology can be measured by the publication of scientific research. In 1995, 25 882 scientific publications were produced in Canada. Since 1980 both Canadian and world output of publications have increased over 60% (Table 4.3.4).

Areas of specialization of Canadian science publications include earth sciences (Canada is the third-largest producer, with 8.2% of world output), biology (7.8%), mathematics (5.8%), and applied science and engineering (5.4%). However, Canadian science publications are under-represented in physics and chemistry, with 3.3% and 3.5%, respectively, of world output in these areas (Table 4.3.5). Environment Canada scientists authored 25% of Canada's 501 environmental science articles and 34% of Canada's 197 meteorology and atmospheric science publications in 1995.[1]

Table 4.3.4
Total Number of Scientific Publications, 1980-1995

Year	Canada	World	Canada as a share of the world
	number		percent
1980	16 048	379 890	4.22
1985	20 113	454 201	4.43
1990	22 979	519 407	4.42
1995	25 882	622 204	4.16

Source:
Godin, B., Y. Gingras and L. Davignon, 1998, *Knowledge Flows in Canada as Measured by Bibliometrics*, Statistics Canada, Science and Technology Working Paper 88F0006XIB ST 98-10, Ottawa.

1. Environment Canada, 1998, *Environment Canada's Scientific Research Publications in 1995*, Draft Report, Science Policy Division, Hull.

Table 4.3.5
Canadian Share of World Scientific Publications by Subject, 1995

Subject	Canada	World	Canada as a share of the world
	number		percent
Clinical medicine	7 242	158 389	4.57
Biomedical research	4 036	81 487	4.95
Physics	2 465	73 756	3.34
Chemistry	2 229	64 320	3.47
Applied science and engineering	2 261	42 282	5.35
Biology	2 971	38 265	7.76
Earth science	2 188	26 770	8.17
Mathematics	518	8 865	5.84
Unknown	1 972	45 003	4.38

Source:
Godin, B., Y. Gingras and L. Davignon, 1998, *Knowledge Flows in Canada as Measured by Bibliometrics*, Statistics Canada, Science and Technology Working Paper 88F0006XIB ST 98-10, Ottawa.

Inventions

Applying for a patent is one way of establishing the right to use and license a discovery or invention. Canada's patent office processes over 40 000 patent applications each year. In 1995, only 2 467 (or 5.7%) of these applications came from resident inventors; the rest were submitted by foreign inventors.[1] However, Canadian inventors applied for 52 771 patents in other countries. Because of the patent laws in other countries, Canadian inventors are often at an advantage to patent in the United States and Japan before patenting in Canada.

The only recent statistical information on the nature of Canadian inventions is derived from an analysis of the U.S. patent database. Of the 16 283 patents issued to Canadians between 1990 and 1996, the two largest categories were earth working and other civil engineering (9.2%), and agriculture and farming (4.9%).

4.3.3 The applications of science and technology

The lives of Canadians have been transformed by technological developments (Text Box 4.3.2). In 1900, the telephone, electric lighting and the internal combustion engine were available but scarce. Telephone service and electricity were largely provided by small independent companies serving a single town. Most houses were lit by kerosene lamps. Trains, boats and fire engines were powered by coal-fired steam engines. In 1903, only 178 motor cars were registered in all of Canada.

In 1911, when national telephone statistics were first available, Canada's 303 000 telephones (about one for every 20 people) were managed by 537 companies, rural clubs and telephone associations.[2] While the telephone has been an almost universal appliance in Canadian homes for the last half-century, information technologies such as cable television, cellular telephones and computers have quickly increased over the past 10 years. In 1996, 98.7% of Canadian homes had telephones, 74.0% cable television, 31.6% computers and 14.1% cellular telephones. During that year, 7.4% of all households used the Internet.[3]

Computer use on farms doubled from 11% to 21% between 1991 and 1996.[4] With farms becoming larger and more specialized, computers are now used to help make production decisions. Internet penetration to rural areas is slow because of inadequate phone lines and a lack of service providers in some areas.

Text Box 4.3.2
Prescott, Ontario: Technology in a Small Town

Prescott, Ontario, a small community of about 3 000, saw its first electrical street lighting in 1889. A local steam generator powered the lights. In 1900, Prescott's 70 telephone subscribers were provided with "continuous service, except on Sundays, from 7:30 to 9:30 a.m., 10:30 a.m. to 1:30 p.m., 2 to 5 p.m. and 6 to 8 p.m." This allowed the local manager time for meals and church attendance and encouraged fellow citizens not to make undue use of their telephone on the Day of Rest.[1]

At the turn of the 20th century, the first water tower was constructed and residents switched from pumped to piped water. Streets and sidewalks were paved for the first time.

Prescott was a transfer point for rail and river transport. Steam trains ran to Ottawa, Toronto and Montréal. In 1900, a second set of train tracks was laid from Toronto to Montréal to accommodate the traffic. Local transportation was by horse-drawn coach. The first automobile was not registered in Prescott until 1910. Steam-powered ferries carried passengers and rail cars across the St. Lawrence River to Ogdensburg, New York. Steamboats arrived from Toronto and Kingston. Passengers destined for Montréal would transfer here to specialized boats that could traverse the rapids at Iroquois.

1. Morris, J.A., 1967, *Prescott 1810-1967*, St. Lawrence Printing Company Limited, Prescott.

1. Organisation for Economic Co-operation and Development (OECD), 1998, *Main Science and Technology Indicators*, Paris.

2. Department of Railways and Canals, 1912, *Telephone Statistics, 1911*, No. 20b-1912, Ottawa.
3. Statistics Canada, 1997, "Access to the information highway, the sequel," *Services Indicators*, 1st Quarter, Vol. 3, No. 4, Catalogue No. 63-016-XPB, Ottawa.
4. Statistics Canada, 1997, *Farming Facts 1997*, Catalogue No. 21-522-XPE, Ottawa.

Text Box 4.3.3

Biotechnologies Explained

The following is a description of the biotechnologies within the three main groups:

Selection and/or modification of biological material

- *Recombinant DNA*: A procedure used to join together DNA segments outside a cell. Also referred to as genetic engineering.
- *Antibodies*: Proteins produced in the body in response to the introduction of foreign molecules called antigens.
- *Peptide synthesis:* A procedure to join two or more amino acids by a linkage called a peptide bond.
- *Rational drug design*: An analysis of the structures of active sites of enzymes and receptors, made in order to design pharmacologically active synthetic molecules that will fit these analysed structures.
- *Monoclonal antibodies*: A highly specific antibody that is derived from one line of cells and recognizes only one specific complementary antigen.
- *Gene probe*: A section of DNA of known structure or function that is marked with a radioactive isotope, dye or enzyme so that it can be used to detect the presence of specific sequences of bases in another DNA molecule.
- *Gene therapy*: The replacement of a defective gene in an organism suffering from a genetic disease.
- *DNA amplification*: The process of increasing the number of copies of a particular gene or chromosomal sequence.

Environmental biotechnologies

- *Bioaugmentation*: The process of increasing the efficiency of the naturally occurring microbial population to concentrate or accumulate specific compounds (usually achieved by adding nutrients, oxygen or water).
- *Bioremediation*: A process that involves the use of naturally occurring or genetically modified micro-organisms to break down or degrade hazardous substances into less hazardous or non-toxic substances.
- *Bioreactors*: Enclosed containers in which micro-organisms are maintained under controlled conditions for the purpose of creating or destroying specific compounds.
- *Phytoremediation*: The use of vegetative species for site remediation.
- *Biological gas cleaning*: The use of micro-organisms to break down or degrade hazardous substances in a gas stream into less hazardous or non-toxic substances.

Culture and/or use of biological material

- *Tissue culture*: The propagation or growth, in a nutrient medium in a laboratory environment, of cells that are isolated from organisms.
- *Somatic embryogenesis*: The propagation of genetically desirable plant and tree lineages by tissue culture methods.
- *Biobleaching*: The use of micro-organisms to bleach pulp.
- *Biopesticide*: The use of naturally occurring microbes or bacteria to control pests.
- *Classical/traditional breeding*: The genetic improvement of animals or plants by breeding selected individuals.
- *Bioprocessing*: Production stages that include fermentation, recovery and purification.
- *Biosensing*: The use of a biological molecule (e.g., an enzyme or an antibody) in conjunction with a transducer for low-level detection of substances such as sugars and proteins in body fluids, pollutants in water, etc.
- *Bioleaching*: Use of micro-organisms to leach metals from ore.
- *Microbioinoculants*: Naturally occurring bacterial inoculants used to promote plant growth.

Source:
Statistics Canada, 1996, *Survey of Biotechnology Use in Canadian Industries - 1996*, Form 5-4700-40.1, Ottawa.

Focus on biotechnologies

Biotechnologies are a group of widely different processes that use living organisms or genetic materials to develop new products. The processes draw from agricultural, biological, chemical and medical sciences, and the products are used extensively in agriculture, drug manufacturing and medical treatment as well as pollution control. These products can be classified into three general groups: selection and/or modification of biological material; environmental biotechnologies; and culture and/or use of biological material (see Text Box 4.3.3 for definitions).

Biotechnologies are used throughout Canadian businesses; 14% of businesses employ one or more types.[1] Overall, the most prevalent biotechnology is bioremediation, which is widely used in the resource-based industries (mining/oil well, and pulp and paper). Bioremediation use ranges from 62% in petroleum refining to 25% in mining. The use rates for environmental biotechnologies drop substantially in the manufacturing sector. The food sector is the largest user, although the highest utilization rate is only 11% for bioaugmentation.

1. Arundel, A., 1999, *Diffusion of Biotechnologies in Canada*, Science and Technology Redesign Project Research Paper, Statistics Canada Monograph No. 88F0017MPB, No. 6, Ottawa.

Industry profiles

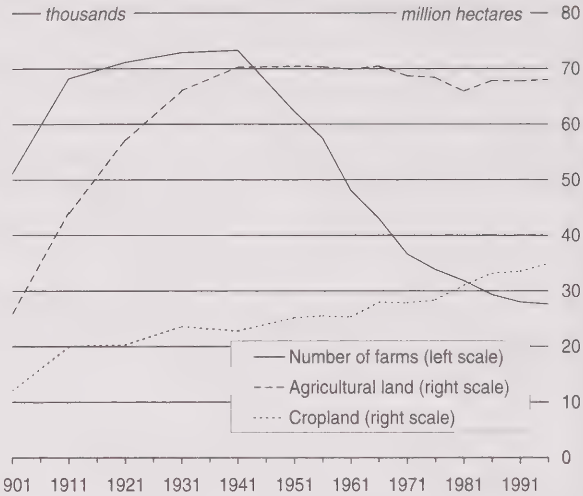
Industry has had an enormous impact on Canada in both human and environmental terms. It is no exaggeration to say that the country's history cannot be understood apart from the story of the discovery and exploitation of rich natural resources. European explorers were quickly followed by traders and merchants who found a ready market for the wealth of Canada's forests, waters and soil.

Since that time, the agriculture, fishing, forest and mining industries—different as they are—have shared a common trajectory: an initial period of rapid expansion accompanied by high rates of employment, followed by a time of equally rapid mechanization and declining numbers of workers. The development of these industries has also raised issues concerning land use, the depletion and conservation of natural resources, and the introduction of pollutants into the environment. On the economic side, the industries have at once made significant contributions to the Canadian GDP and made the labour of many workers redundant through the use of advanced technology.

4.4 Agriculture

At the turn of the 19th century, 80% of the Canadian population lived in rural areas. Lower Canada (Quebec) was one of the more developed settlement areas of North America. In contrast, Upper Canada (Ontario) had just begun its agricultural development. The growing international market for wheat, the influx of large numbers of immigrants and the political will to develop the rail network across the continent prompted the agricultural colonization of western Canada.[1,2] Land clearing progressed quickly.

Figure 4.4.1
Number of Farms, Agricultural Land and Cropland, 1901-1996



Sources:
Statistics Canada, 1983, *Historical Statistics of Canada, Second Edition*, F.H. Leacy (ed.), Catalogue No. 11-516E, Ottawa.
Statistics Canada, 1997, *Historical Overview of Canadian Agriculture*, Catalogue No. 93-358-XPB, Ottawa.

In 1871, there were 367 862 farms in Canada (Table 4.4.1). By the beginning of the 20th century, that number had increased to 511 073 farms, employing about 700 000 male workers.[3] During this period, average farm size remained constant in eastern Canada. However, in Canada as a

1. Fairbairn, G.L., 1984, *Will the Bounty End? The Uncertain Future of Canada's Food Supply*, Agricultural Institute of Canada, Saskatoon.
2. Gentilcore, L. and G.J. Matthews (eds.), 1993, *Historical Atlas of Canada, Volume II: The Land Transformed, 1800-1891*, University of Toronto Press, Toronto.
3. Statistics Canada, 1983, *Historical Statistics of Canada*, Second Edition, F.H. Leacy (ed.), Catalogue No. 11-516E, Ottawa.

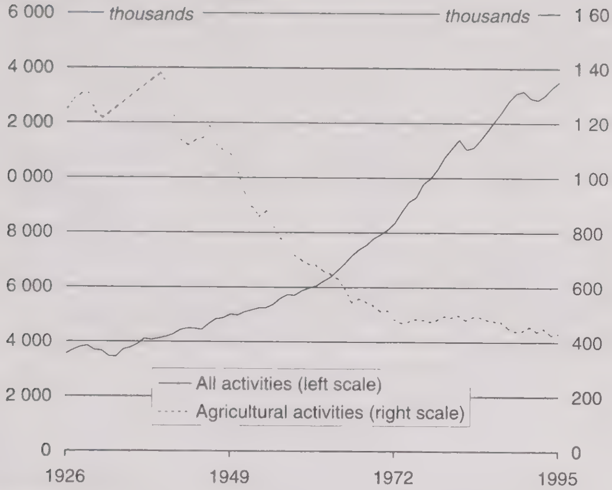
Table 4.4.1
Number of Farms by Province, 1871-1996

Year	Nfld.	P.E.I.	N.S.	N.B.	Que.	Ont.	Man.	Sask.	Alta.	B.C.	Total
1871	...	...	46 316	31 202	118 086	172 258	...	...	...	...	**367 862**
1881	...	13 629	55 873	36 837	137 863	206 989	9 077	1 014[2]	...	2 743	**464 025**
1891[1]	...	14 549	60 122	38 577	174 996	216 195	22 008	9 244[3]	...	6 490	**542 181**
1901[1]	...	13 748	54 478	37 006	140 110	204 054	32 252	13 445	9 479	6 501	**511 073**
1911[1]	...	14 113	52 491	37 755	149 701	212 108	43 631[4]	95 013[4]	60 559[4]	16 958	**682 329**
1921	...	13 701	47 432	36 655	137 619	198 053	53 252[4]	119 451[4]	82 954[4]	21 973	**711 090**
1931	...	12 865	39 444	34 025	135 957	192 174	54 199	136 472	97 408	26 079	**728 623**
1941	...	12 230	32 977	31 889	154 669	178 204	58 024	138 713	99 732	26 394	**732 832**
1951	3 626	10 137	23 515	26 431	134 336	149 920	52 383	112 018	84 315	26 406	**623 087**
1961	1 752	7 335	12 518	11 786	95 777	121 333	43 306	93 924	73 212	19 934	**480 877**
1971	1 042	4 543	6 008	5 485	61 257	94 722	34 981	76 970	62 702	18 400	**366 110**
1981	679	3 154	5 045	4 063	48 144	82 448	29 442	67 318	58 056	20 012	**318 361**
1991	725	2 361	3 980	3 252	38 076	68 633	25 706	60 840	57 245	19 225	**280 043**
1996	742	2 217	4 453	3 405	35 991	67 520	24 383	56 995	59 007	21 835	**276 548**

Notes:
1. Excludes plots under one acre, to attain comparability with data for later years.
2. Data comprise the portion of the Northwest Territories located west of Manitoba.
3. Data comprise the districts of Assiniboia, Saskatchewan and Alberta.
4. Data exclude farms located on Indian reserves.

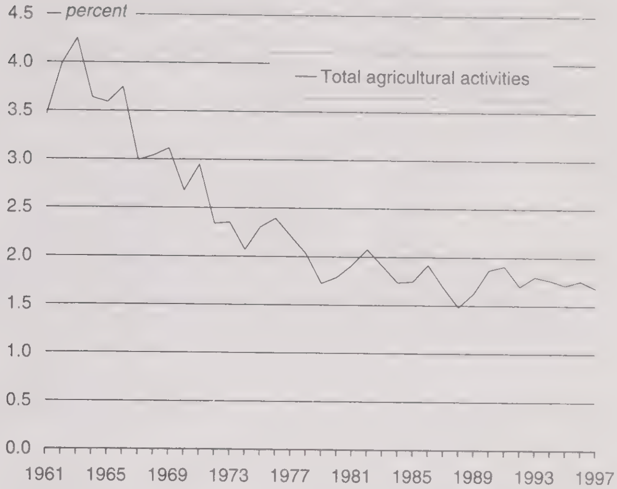
Sources:
Statistics Canada, 1983, *Historical Statistics of Canada, Second Edition*, F.H. Leacy (ed.), Catalogue No. 11-516E, Ottawa.
Statistics Canada, 1997, *Historical Overview of Canadian Agriculture*, Catalogue No. 93-358-XPB, Ottawa.

Figure 4.4.2
Total and Agricultural Labour Force Employed, 1926-1995



Source:
Statistics Canada, CANSIM, matrix 600.

Figure 4.4.3
Agricultural Activities as a Share of GDP, 1961-1997



Source:
Statistics Canada, CANSIM, matrix 4677.

whole, average farm size increased because of the creation of large new farm holdings in western Canada. Western farms were generally larger because lower land productivity required that each farm occupy more land to be economically viable.

During the first half of the 20th century, Canadian agricultural land continued to increase. In 1901, agricultural land in Canada occupied 25.7 million hectares. That figure increased rapidly and reached its historical peak in the early 1950s, at 70.4 million hectares. Cropland, in contrast, grew at a relatively stable rate: it represented 46% of total agricultural land in 1901, reaching 51% in 1996 (Figure 4.4.1).

In the 1800s and early 1900s, the number of farms in Canada increased steadily to a peak of 732 832 farms in 1941 (Table 4.4.1). Since then, the number of farms has been decreasing, with only 276 548 farms remaining by 1996. Since agricultural land area has been stable since the early 1900s, the average size of a farm has increased, from 50 hectares in 1901 to 246 hectares in 1996.

Along with the decline in the number of farms, the number of people directly involved in farming activities has also decreased. While the number of farm labourers remained relatively stable from 1926 to 1939, it has decreased steadily since. As shown in Figure 4.4.2, the number of farmers has declined from a high of 1.4 million in 1939, to a low of around 431 000 in 1995. During the same period, the total Canadian labour force tripled, from 4.1 million in 1939 to 13.5 million in 1995. Farmers made up 35% of the Canadian labour force in 1926, but they represented only 3% in 1995.

Table 4.4.2
Number of Farms by Total Gross Farm Receipts,[1] 1981-1996

Receipts class	Farms				Share of total			
	1981	1986	1991	1996	1981	1986	1991	1996
	number				percent			
Under $2 500	42 104	30 615	23 309	23 709	13.2	10.4	8.3	8.6
$2 500 to $4 999	27 913	21 696	18 814	18 462	8.8	7.4	6.7	6.7
$5 000 to $9 999	34 182	28 828	26 200	26 245	10.7	9.8	9.4	9.5
$10 000 to $24 999	57 175	47 887	46 397	45 195	18.0	16.3	16.6	16.3
$25 000 to $49 999	55 459	45 374	42 253	37 751	17.4	15.5	15.1	13.7
$50 000 to $99 999	52 819	52 325	48 165	42 046	16.6	17.9	17.2	15.2
$100 000 to $249 999	37 858	50 004	53 211	55 198	11.9	17.1	19.0	20.0
$250 000 to $499 999	7 834	11 952	15 347	19 268	2.5	4.1	5.5	7.0
$500 000 and over	3 017	4 408	6 347	8 674	0.9	1.5	2.3	3.1
Total	**318 361**	**293 089**	**280 043**	**276 548**	**100.0**	**100.0**	**100.0**	**100.0**

Note:
1. Farm receipts are in 1995 dollars.
Source:
Statistics Canada, 1997, *Historical Overview of Canadian Agriculture*, Catalogue No. 93-358-XPB, Ottawa.

Table 4.4.3
Agricultural Technology Indicators, 1921-1996

Year	Total agricultural land	Cropland area	Agricultural labour force	Workers per area of agricultural land	Fertilizers[1]	Fertilizers per area of cropland	Tractors and combines	Tractors and combines per area of cropland
	thousand hectares		thousand workers	workers per thousand hectares	thousand tonnes	tonnes per thousand hectares	number	number per thousand hectares
1921	57 015	20 248	1 025	18	..	..	47 455[2]	2
1931	66 010	23 609	1 216	18	254	11	114 227	5
1941	70 239	22 776	1 224	17	289	13	178 765	8
1951	70 434	25 176	939	13	688	27	490 186	19
1961	69 825	25 266	681	10	961	38	705 400	28
1971	68 661	27 828	514	7	1 885	68	759 449	27
1981	65 889	30 966	498	8	3 501	113	818 716	26
1991	67 754	33 508	457	7	3 811	114	886 263	26
1996	68 055	34 919	453	7	4 378	125	843 788	24

Notes:
1. Refers to application of commercial fertilizer only and not to applications of manure produced on the farm. Until 1978 these data were obtained from the *Annual Fertilizer Dealer Survey,* which included all fertilizer for sale by dealers. A small amount of this fertilizer was for non-agricultural uses (i.e., households, institutions and governments). The 1981-1996 quantities of fertilizers are obtained from the Census of Agriculture, and are therefore not necessarily comparable to those of previous years.
2. Includes only tractors.

Sources:
Statistics Canada, 1986, *Human Activity and the Environment, A Statistical Compendium*, Catalogue No. 11-509E, Ottawa.
Statistics Canada, 1997, *Historical Overview of Canadian Agriculture*, Catalogue No. 93-358-XPB, Ottawa.
Statistics Canada, CANSIM, matrices 600 and 3450.

Figure 4.4.3 demonstrates that the share of agricultural activities declined by half between 1960 and 1997. At the same time, farm revenue, as represented by gross farm receipts, has been increasing (Table 4.4.2). In 1981, 15% of farms had a revenue in excess of $100 000. By 1996 this share had increased to 30%.

4.4.1 Agricultural driving forces

During the 20th century, industrialization has influenced agriculture directly by modifying the way farming activities are conducted and managed. Two of the most important impacts of industrialization were in mechanical and chemical developments.

Mechanized power

The mechanization of agriculture has grown rapidly during this century. Between 1921 and 1996, the number of tractors and combines in Canada increased by a factor of nearly 18 (Table 4.4.3). In 1921, there were two tractors and combines per thousand hectares of cropland. By 1996, that number had increased to 24. In 1921, there were 22 agricultural workers for every tractor and combine. By 1996, there were more tractors and combines than there were agricultural workers. As a result of mechanization, the 1901 average of 28 agricultural workers per thousand hectares of cropland had dropped to 7 in 1996.

Agricultural chemicals

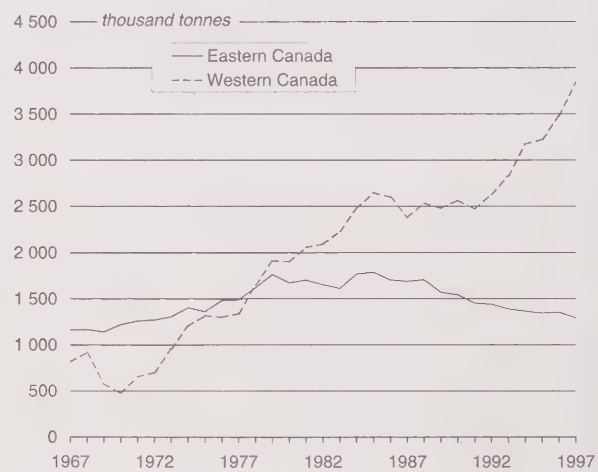
Agriculture has also become increasingly reliant on chemical inputs. Nitrogen fertilizers increase agricultural production by enhancing the soil's natural potential (Text Box 4.4.1). Around 254 000 tonnes of fertilizer were used in

Text Box 4.4.1
Nitrogen Fertilizer

The process that allows the synthetic production of nitrogen fertilizer, the Haber-Bosch ammonia synthesis process, was invented in the early part of the century. Its creator, Fritz Haber (1868-1934), received a 1919 Nobel prize for the discovery. Approximately one-third of the protein that sustains today's world population comes from this source.

Source:
Smil, V., 1997, "Global Population and the Nitrogen Cycle," in *Scientific American*, Vol. 277, No.1, July, pp. 76-81.

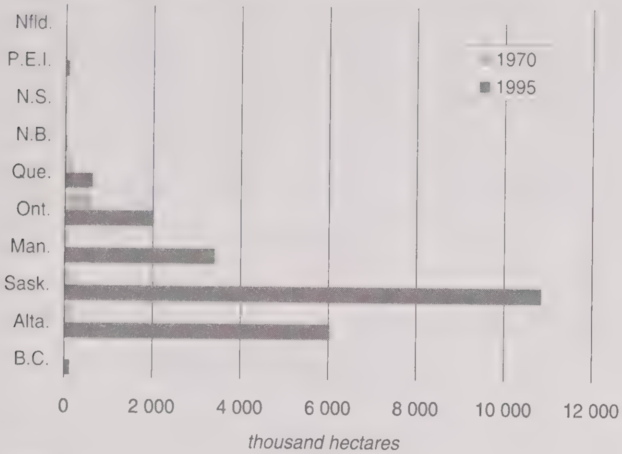
Figure 4.4.4
Fertilizers Sold in Eastern[1] and Western Canada, 1967-1997



Note:
1. Eastern Canada corresponds to provinces east of Manitoba, while western Canada corresponds to provinces west of Ontario.

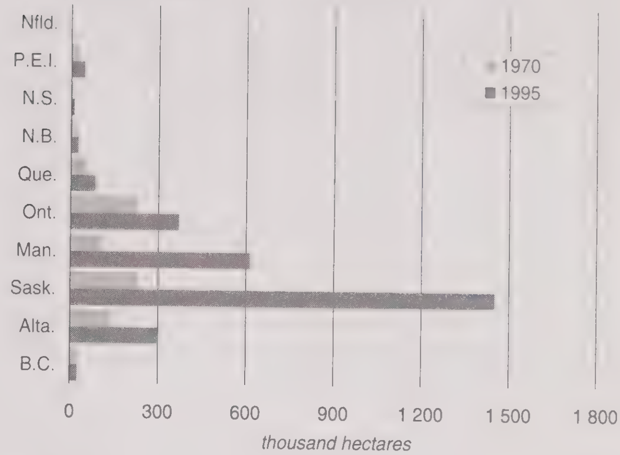
Source:
Korol, M. and G. Rattray, 1998, *Canadian Fertilizer Consumption, Shipments and Trade, 1996/1997*, Farm Inputs Markets Unit, Farm Income Policy and Programs Directorate, Agriculture and Agri-food Canada, Ottawa.

Figure 4.4.5
Area Treated with Herbicides by Province, 1970 and 1995



Source:
Statistics Canada, Census of Agriculture.

Figure 4.4.6
Area Treated with Insecticides by Province, 1970 and 1995



Source:
Statistics Canada, Census of Agriculture.

Canada in 1931 (Table 4.4.3). In 1996, Canadian farmers used 4.4 million tonnes of fertilizer, which is 17 times the amount applied in 1931. In eastern Canada, sales of fertilizers grew by 11% between 1967 and 1997. In the west, where most of the agricultural land lies, sales increased by 370% during the same period (Figure 4.4.4).

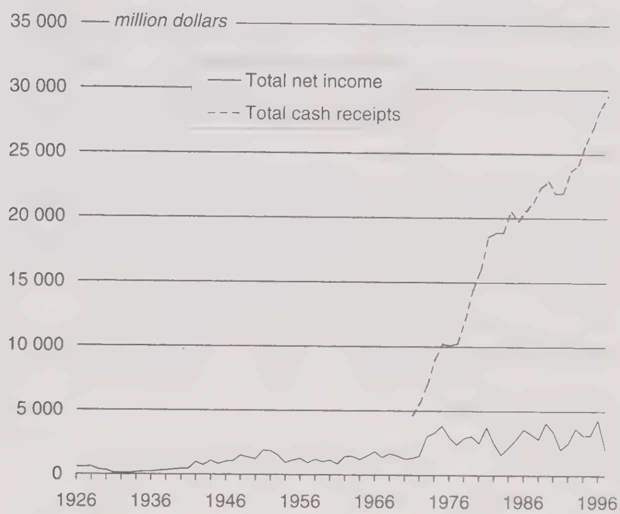
The rapid development of the chemical industry, mainly since the Second World War, has also led to the widespread adoption of chemical pesticides, which include herbicides, insecticides and fungicides. Figure 4.4.5 demonstrates the rapid increase in the area treated with chemical herbicides. In 1970, Ontario was the province with the largest area treated with herbicides (47% of Canada's total). By 1995, the area treated with herbicides had increased by 18-fold nationally, with Saskatchewan treating the largest area of any province.[1]

The use of chemical insecticides is also on the rise (Figure 4.4.6). The area treated with chemical insecticides increased 3.5 times between 1970 and 1995.[2]

4.4.2 Agriculture today

Mechanical and chemical developments in agriculture have changed the way agriculture is conducted. These technological advances have resulted in the increase of both monoculture farms and "megafarms" (consolidated farms). The industrialization of agriculture has changed the way farms are managed. This is apparent when comparing farm income and receipts (Figure 4.4.7). Total cash receipts and operating expenses have increased sharply since the 1970s, while total net income for farmers remained below $5 billion throughout the century. As a result, net farm income, as a share of total farm cash receipts, has dwindled from 28% in 1971, to 6% in 1997 (Figure 4.4.8).

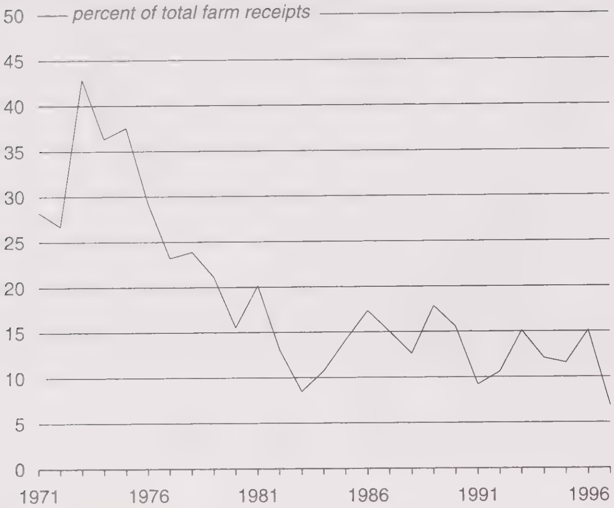
Figure 4.4.7
Agricultural Net Income and Cash Receipts, 1926-1997



Source:
Statistics Canada, CANSIM, matrix 263.

1. It should be noted that these figures do not indicate the volume or the concentration of herbicides applied.
2. It should be noted that these figures do not indicate the volume or the concentration of insecticides applied.

Figure 4.4.8
Net Farm Income, 1971-1997



Source:
Statistics Canada, CANSIM, matrix 263.

Agriculture has become more capital-intensive and more reliant on farm inputs. This has prompted the development of the service sector dedicated to farming activities. At one end, service industries[1] incidental to the agricultural sector have achieved the largest labour force growth rate of all industrial groups over the 1986–1996 decade—a 49% increase. At the other end, food processing industries have also benefited from the industrialization of agriculture. In 1996, Canada's food processing industries[2] employed around 228 000 people, accounting for 11% of total manufacturing employment. The food processing industries group is Canada's second-largest manufacturing industries group.

1. These service industries include establishments primarily engaged in providing services to livestock and animals (such as Veterinary Services; Farm Animal Breeding Services; and Poultry Services) and to agricultural crops (such as Soil Preparation, Planting and Cultivating Services; Crop Dusting and Spraying Services; and Harvesting, Baling and Threshing Services).
2. Food processing industries include the following: Meat and Poultry Products; Fish Products; Fruit and Vegetable; Dairy Products; Flour, Prepared Cereal Food and Feed; Vegetable Oil Mills; Bakery Products; Sugar and Sugar Confectionery; and Other Food Products.

4.5 Fisheries

Statistics Canada divides fishing-related activities into two industries: Fishing and Trapping, and Fish Products. The Fishing and Trapping Industry is made up of those businesses and individuals engaged directly in fishing (including fish farm operators) as well as those that offer services such as inspections to fishers.[1] The Fish Products Industry is made up of businesses that process fish into food products. Collectively, these industries will be referred to here as the fishing industries.

4.5.1 Gross Domestic Product and employment

In 1989, the fishing industries contributed $2.0 billion to GDP, or 0.33% of the national total (Table 4.5.1). Their contribution fell throughout the 1990s and they accounted for only $1.7 billion of GDP, or 0.25% of the national total, in 1997.

The decline in the fishing industries' GDP was mirrored by a similar trend in employment (Table 4.5.2). In 1989, 76 300 people, or 0.58% of the national work force, worked in the fishing industries. By 1997, this number had fallen to 60 700 people, or just 0.44% of those employed across the country. While employment in both of the fishing industries declined, it dropped more notably in the Fish Products Industry.

Table 4.5.1
Gross Domestic Product of Fishing Industries, 1989-1997

Year	Total GDP	Fishing industries: Fishing and Trapping	Fish Products	Total	Share of total GDP
	million dollars				percent
1989	607 564	1 123	872	1 995	0.33
1990	609 231	1 260	954	2 214	0.36
1991	600 004	1 116	889	2 005	0.33
1992	604 275	1 026	794	1 820	0.30
1993	619 194	1 058	817	1 875	0.30
1994	643 063	927	830	1 757	0.27
1995	655 088	801	823	1 624	0.25
1996	665 277	851	856	1 707	0.26
1997	691 361	893	852	1 745	0.25

Source:
Statistics Canada, *Gross Domestic Product by Industry*, Catalogue No. 15-001-XPB, Ottawa.

1. Trapping comprises a relatively small part of the Fishing and Trapping Industry. In 1996, 86% of the people employed in the industry fished, 10% offered fishing-related services and 4% trapped. From a revenue perspective, 1996 fish landings were worth $1.5 billion, while the pelts produced that same year were valued at $34 million.

Table 4.5.2
Employment in the Fishing Industries, 1989-1997

Year	Total employment	Fishing industries: Fishing and Trapping	Fish Products	Total	Share of total employment
	thousand persons				percent
1989	13 086	41.3	35.0	76.3	0.58
1990	13 165	42.6	31.4	74.0	0.56
1991	12 916	47.6	30.0	77.6	0.60
1992	12 842	40.0	29.4	69.4	0.54
1993	13 015	41.9	25.8	67.7	0.52
1994	13 292	40.7	24.9	65.6	0.49
1995	13 506	33.0	22.4	55.4	0.41
1996	13 676	35.6	21.4	57.0	0.42
1997	13 941	35.9	24.8	60.7	0.44

Source:
Statistics Canada, *Historical Labour Force Statistics*, Catalogue No. 71-201-XPB, Ottawa.

4.5.2 International trade

Trade in fish and fish products for the period 1989 to 1997 is presented in Table 4.5.3. As can be seen, Canada has traditionally been a net exporter of these products. In 1989, the country exported $2.4 billion worth of fish and fish products, representing 1.63% of all exports. Although the value of these exports increased steadily over the 1990s, it did not keep pace with total exports. The $3.0 billion worth of fish and fish products exported in 1997 accounted for only 1.01% of all exports.

Looking at imports, fish and fish products' share has been more stable. In 1989, $787 million worth of these goods was imported, which amounted to 0.57% of total imports. The corresponding figures in 1997 were $1.6 billion and 0.57%.

Canada's trade surplus in fish and fish products declined significantly in relative terms over this period. In 1989, imports of fish and fish products amounted to only 33% of exports; by 1997, this figure had risen to 52%.

Table 4.5.3
Exports and Imports of Fish and Fish Products, 1989-1997

Year	Exports: Total	Exports: Fish and fish products	Exports: Share of total exports	Imports: Total	Imports: Fish and fish products	Imports: Share of total imports
	million dollars		percent	million dollars		percent
1989	146 963	2 401	1.63	139 216	787	0.57
1990	152 056	2 626	1.73	141 000	731	0.52
1991	147 669	2 460	1.67	140 658	782	0.56
1992	163 464	2 491	1.52	154 430	839	0.54
1993	190 383	2 594	1.36	177 593	1 070	0.60
1994	227 892	2 902	1.27	208 590	1 260	0.60
1995	264 938	3 060	1.15	231 206	1 436	0.62
1996	280 566	2 970	1.06	239 577	1 601	0.67
1997	301 601	3 038	1.01	278 237	1 578	0.57

Source:
Statistics Canada, International Trade Division.

4.5.3 The regional fishing industries

The figures presented above show a relatively modest contribution to the national economy on the part of the fishing industries. Despite this, fishing is the mainstay of economic life in nearly 1 500 coastal communities in Canada.[1] Declining fish stocks and government restrictions on fishing have placed mounting pressures on these communities in recent years. Given these conditions, the regional characteristics of the fishing industries deserve a closer look.

Atlantic Canada: The decline in groundfish stocks

Beginning in the late 1980s, many of the groundfish species traditionally fished in the Atlantic provinces[2] experienced severe stock reductions. In an effort to allow stocks time to recover, the federal government imposed moratoria on many of the Atlantic groundfish fisheries.

One of the most obvious effects of these events was a decline in employment in the Atlantic fishing industries. In 1989, these industries employed 60 000 people, representing 1.5% of total employment in the region. By 1996, they employed only 43 000 people, or 1.0% of the total regional work force.[3]

Declining employment in the fishery was likely one of the factors behind the significant emigration from the Atlantic provinces between 1991 and 1996. During this period, nearly 68 000 more people moved away from an Atlantic province than moved to one. The province of Newfoundland alone lost a record 23 000 people. In the case of three provinces—Newfoundland, Nova Scotia and New Brunswick—about three-quarters of those who moved away left Atlantic Canada entirely.[4]

The stock declines and ensuing moratoria also dramatically reduced groundfish catches in Atlantic Canada. In 1989, nearly 685 000 tonnes of groundfish were brought to shore in the Atlantic provinces, accounting for 52% of all fish landings in the region. The value of this catch was $359 million, or 37% of the regional total. By 1996, groundfish accounted for only 116 000 tonnes, or 17% of all Atlantic landings, a decrease of 83% from 1989. The value of the groundfish landed in 1996 was just $120 million, or 11% of the regional total. This represented a decline of 67% from 1989.

1. Environment Canada, 1996, *The State of Canada's Environment 1996*, Ottawa.
2. In this context, the Atlantic provinces include Newfoundland, Prince Edward Island, New Brunswick, Nova Scotia and Quebec.
3. Statistics Canada, Labour Force Survey.
4. Statistics Canada, Census of Population 1996.

It is interesting to note that while groundfish landings were falling in the 1990s, shellfish landings were growing impressively—particularly in dollar value. In 1989, the Atlantic provinces landed 228 000 tonnes of shellfish worth $504 million. By 1996, shellfish landings had risen to 281 000 tonnes with a value of $897 million—increases of 23% and 78% respectively. These figures reflect in part two forces: an increase in the intensity with which shellfish—lobster, shrimp and crab in particular—were harvested as groundfish stocks declined; and a cyclical high point in shellfish stocks during this period.[5]

Text Box 4.5.1

Newfoundland: Living with the Decline of Cod Stocks

Cod experienced the most drastic stock decline of any groundfish species in the 1990s. Newfoundland in particular suffered from this decline and the ensuing moratoria on cod fishing. In 1989, cod made up 50% (262 000 tonnes) of Newfoundland's fish landings, a harvest that was worth $120 million or 45% of the value of the province's total landings. By 1996, several years after the implementation of full moratoria on cod fishing, landings had fallen to a mere 1 000 tonnes valued at just $1 million.

As elsewhere in Atlantic Canada, Newfoundland's shellfish harvest increased as its groundfish harvest fell. Indeed, this response was particularly marked in Newfoundland. While this province accounted for just 19% (43 000 tonnes) of Atlantic Canada's shellfish landings in 1989, by 1996 39% (109 000 tonnes) of the region's shellfish harvest was landed in Newfoundland. This increase, combined with rising shellfish prices, meant that the value of Newfoundland's total fish landings actually increased from $266 million in 1989 to $289 million in 1996.

Employment did not follow the same trend, however. In 1989, 23 600 Newfoundlanders were employed in the fishing industries, representing 12% of the province's total employment. By 1996, fishing employment had dropped to 14 800 people or 7% of total employment.

The social implications of these job losses—emigration, for instance—are magnified in Newfoundland's small fishing outports. Residents of these towns fish not only as a source of income, but also as a way of life. Population in three such towns, St. Anthony, Portugal Cove South and Burgeo, declined on average 29% between 1991 and 1996. In Newfoundland as a whole, population fell from 568 000 people to 552 000 people (3%) over the same period. No other province experienced a net decline in population during this time.

5. Department of FIsheries and Oceans, Statistical Services.

Table 4.5.4
Federal Programs Addressing the Atlantic Groundfish Decline, 1990-1998

	Program			
	Atlantic Fisheries Adjustment Program/Quebec Federal Fisheries Department Program 1990-1995	**Northern Cod Adjustment and Recovery Program 1992-1994**	**Atlantic Groundfish Adjustment Program and Related Programs 1993-1994**	**Atlantic Groundfish Strategy 1994-1998**
Resources[1]	$637 million	$587 million	$381 million	$1.9 billion
Objectives	rebuild groundfish stocks adjust to current economic and social realities facilitate economic diversification of communities	respond to immediate income needs facilitate more economically and environmentally sustainable northern cod fishing industries	respond to immediate income needs enhance employment opportunities develop new skills	renew groundfish stocks and reduce harvesting and processing capacity facilitate labour adjustment facilitate community economic development
Implementation	Fisheries and Oceans Canada Employment and Immigration Canada Labour Canada Atlantic Canada Opportunities Agency Federal Office of Regional Development (Quebec Office)	Fisheries and Oceans Canada Employment and Immigration Canada	Fisheries and Oceans Canada Human Resources Development Canada Atlantic Canada Opportunities Agency	Fisheries and Oceans Canada Human Resources Development Canada Atlantic Canada Opportunities Agency Federal Office of Regional Development (Quebec Office)
Elements	income support community economic development and diversification new inputs into stock assessments	income support job training and early retirement packages licence retirement assistance in maintaining vessels and gear	income support job training and development of employment opportunities assistance designed to support those moving out of the fishing industries community economic development and diversification assistance in maintaining vessels and gear partnerships between various management bodies	income support job training community economic development and diversification revised management of fishing industries

Note:
1. Main estimates.
Source:
Office of the Auditor General.

For more complete data on fish landings in Atlantic Canada, see section 5.3–**Marine resources**.

Following the decline of the Atlantic groundfish stocks, the federal government attempted through a series of support programs to provide income security and improve job prospects for displaced fishers and fish plant workers. These efforts began in the late 1980s with programs designed to cover failures in localized fisheries. They evolved to include larger, more comprehensive programs in the 1990s (Table 4.5.4).

The West Coast: Difficult times in the salmon fishery

The British Columbia fishing industries have been built largely on the harvesting of sockeye, pink, chum, chinook and coho salmon. In 1989, the province's salmon catch amounted to 89 000 tonnes, some 31% of all fish landings. More impressively, salmon represented 56% ($256 million) of the total landed value on the West Coast in that year.

In more recent years, the province's salmon fishery has been negatively affected by two trends. First, a marked decline in salmon stocks was noted beginning in 1995. Second, shifts in the world seafood market caused prices for some species to decline substantially.[1] The results were some of the smallest salmon harvests on record. In 1996, only 34 000 tonnes of salmon were landed. At just 14% of total provincial landings, this was a decline of 61% from 1989. The value of this harvest was just $99 million, or 23% of total landed value that year, a decline of 62% from 1989.

Despite events in the salmon fishery, British Columbia's overall fishing industries fared relatively well in the 1990s. In 1996, total fish landings were 242 000 tonnes ($424 million), down just 16% from the 287 000 tonnes ($454 million) landed in 1989.

As in Atlantic Canada, the West Coast fishing industries have weathered their recent difficulties largely thanks to an increase in the shellfish harvest. In 1989, 21 000 tonnes of shellfish valued at $45 million were landed on the West Coast, while in 1996, 29 000 tonnes of shellfish valued at $119 million were landed. While the shellfish catch increased by only 38%, the value increased by a substantial 164%.[2]

For more complete data on fish landings in British Columbia, see section 5.3–**Marine resources**.

1. Department of Fisheries and Oceans, Pacific Region, Coho Response Team, 1998, *Coho Final Report*, Victoria.
2. Department of Fisheries and Oceans, Statistical Services.

At the same time as the salmon harvest dropped, employment in the British Columbia fishing industries also fell. In 1989, 12 400 people—0.81% of the provincial work force—were employed in the fishing industries. By 1996, employment had dropped to 10 100 people or 0.56% of total employment. Most of the decline was attributable to fewer persons actually fishing; fish processing employment remained nearly steady over the period.[1]

In an attempt to address the challenges facing the British Columbia fishing industries, the federal government provided approximately $220 million in financial assistance to displaced workers between 1996 and 1998. A substantial portion of this funding went to finance those who left the industry in pursuit of other ocean-based commercial opportunities.[2]

Inland commercial fisheries

Canada's inland (freshwater) commercial fisheries are relatively small in comparison with its ocean fisheries. In 1996, the freshwater fisheries landed 58 000 tonnes of fish with a value of $64 million.[3] The principal species caught were lake whitefish, yellow pickerel and perch.

4.5.4 Recreational fishing[4]

Many people fish for pleasure rather than for profit. In 1995 alone, 4.2 million adults[5] did so in Canada. The vast majority of these anglers (79%) were Canadians who fished in their home province or territory. Canadians who fished in a jurisdiction other than where they lived made up only 4% of recreational anglers; British Columbia welcomed 43% of these non-resident Canadian anglers.

Fishing enthusiasts from other countries made up 18% of those who fished Canadian waters. This amounted to some three-quarters of a million people visiting Canada to fish in 1995. For many of these people, fishing was the sole purpose of their visit. Most of them (72%) fished in one of Ontario's lakes or rivers.

In total, the angling population spent $7.4 billion in Canada in 1995, of which $4.9 billion was directly associated with their sport.

Recreational fishers put in over 55 million days in 1995. Most of these days were spent fishing in Ontario (42%) and Quebec (19.6%). Freshwater fishing occupied 94% of angling days. Anglers reported that the most important factors associated with their enjoyment of the sport were unpolluted fish and clean water.

In 1995, adult anglers caught an estimated 254 million fish and kept 113 million of them. Trout alone accounted for 22% of all fish caught and 31% of those retained. Resident Canadian anglers retained on average 30 fish in the year, non-resident Canadians retained on average 10 fish, and foreign anglers retained on average 19 fish.

Survey data suggest an increasing trend toward catch-and-release techniques in recent years. Whereas 51% of all fish reported caught by recreational anglers in 1990 were kept, only 44% of fish caught in 1995 were taken home (Table 4.5.5).[6]

Table 4.5.5
Fish Caught and Kept by Recreational Anglers, 1990 and 1995

Fish	1990 Caught	1990 Kept	1995 Caught	1995 Kept
	number			
Bass	31 736 063	7 330 139	22 297 094	3 931 402
Char	948 026	598 377	485 229	154 937
Cod	3 907 235	3 505 733	106 143	53 060
Flounder	164 221	125 805	107 856	31 526
Grayling	497 505	132 389	612 283	90 653
Kokanee	1 258 410	961 653	844 844	572 684
Mackerel	1 237 261	1 082 759	445 549	315 503
Northern pike	33 425 831	9 912 783	28 297 444	5 772 709
Perch	38 252 450	18 180 452	42 390 514	19 539 067
Pollock	148 071	74 396	..	..
Salmon	7 060 455	3 706 455	4 856 067	2 179 327
Shellfish	..	..	6 267 717	4 972 926
Smelt	25 791 718	24 570 906	13 061 550	9 003 307
Trout	66 456 705	44 767 487	56 055 267	34 625 868
Walleye	45 605 352	20 828 541	46 272 809	16 713 297
Whitefish	2 143 544	1 066 664	1 966 535	929 426
Other	44 864 905	19 978 435	30 269 116	14 544 501
Total	**303 497 741**	**156 822 973**	**254 336 017**	**113 430 193**

Note:
Major methodological changes relating to Ontario in the Survey of Recreational Fishing between 1990 and 1995 make the direct comparison of the figures for these two years invalid. Thus, differences in the figures for 1990 and 1995 should only be taken as an indication that differences exist.
Source:
Department of Fisheries and Oceans, Survey of Recreational Fishing in Canada.

1. Statistics Canada, Labour Force Survey.
2. Western Economic Diversification Canada, Department of Fisheries and Oceans and Department of Indian and Northern Development, 1998, "DFO, Western Economic Diversification and DIAND announce fisheries assistance in B.C.," News release NR–PR–98–18E, April 1, Vancouver.
3. Department of Fisheries and Oceans, Statistical Services.
4. Department of Fisheries and Oceans, 1996, *Highlights of the 1995 Survey of Recreational Fishing in Canada*, Ottawa.
5. Adult anglers include those who are over 16 or 18 years of age, depending on the jurisdiction, and those who are licensed in jurisdictions requiring licences.
6. Despite major methodological changes relating to Ontario in the Survey of Recreational Fishing in Canada between 1990 and 1995, it can be said with confidence that there is a clear trend toward catch and release in other provinces and territories.

4.6 Forest industries[1]

The activities of forest-related industries have long been instrumental to the social and economic development of Canada.[2] First considered an impediment to the expansion of agriculture in the New World, timber soon replaced fur as the staple for exports from North America to Europe.[3,4]

It was in the course of the 20th century, however, that the production of logs and bolts, pulpwood and sawn lumber reached its historical highs. In fact, this production is still increasing (Table 4.6.1).

Today, Canada contains over 10% of the world's forests (Text Box 4.6.1). In fact, half of Canada is covered by forest. While the Canadian economy is less dependent on this natural resource today than it once was, the logging industry is still an important and active segment of the national economy. One out of every 17 jobs in Canada depends on this industry.[5] The Logging Industry supplies raw materials mainly to two industry groups: the Sawmill, Planing Mill and Shingle Mill Products Industries; and the Pulp and Paper Industries.[6]

4.6.1 Gross Domestic Product

Gross Domestic Product (GDP) figures for the Logging and Forestry Services industries, the Sawmill, Planing Mill and Shingle Mill Products Industries, and the Pulp and Paper Industries show that they contributed almost $12 billion to the Canadian economy in 1998 (Table 4.6.2). This represents an 85% increase over their contribution in 1961. However, these industries accounted for only 1.7% of GDP in 1998, down from their 3.25% share in 1961.

British Columbia is the province most reliant on the forest and its resources: the Logging, Forestry Services and Wood industries[7] contributed over $2 billion each to the provincial economy in 1997. This represented nearly 5% of the provincial GDP, by far the largest share of any province. In 1995, British Columbia harvested 40% of all marketable timber produced in Canada in an area equal to 21% of Canada's productive forest land.[8]

The Paper and Allied Products Industries[9] are most important in Quebec and Ontario, where they generated

Table 4.6.1
Production of Selected Forest Products, Selected Years

Year	Logs and bolts	Pulpwood	Sawn lumber
		thousand m³	
1922	19 082	11 779	
1930	29 142	17 942	
1940	32 639	26 165	
1950	40 112	40 296	16 462
1960	51 141	42 307	20 788
1970	75 645	40 553	28 371
1980	109 952	38 909	46 577
1990	117 262	35 865	56 534
1995	148 837	31 089	64 572

Sources:
Statistics Canada, 1983, *Historical Statistics of Canada, Second Edition*, F.H. Leacy (ed.), Catalogue No. 11-516E, Ottawa.
Statistics Canada, CANSIM, matrix 6083.

Text Box 4.6.1
The State of the World's Forests

The world's forest area was estimated to be 34.5 million km² in 1995. This area corresponds to a quarter of the earth's land area. Between 1980 and 1995, 1.8 million km² of forest was harvested.

The earth has lost almost half of the forest that covered it 8 000 years ago. Most of this 30 million km² of forest has disappeared in the past three decades. Three countries—Russia, Canada and Brazil—are home to almost 70% of the worlds remaining natural forests.

Sources:
United Nations Food and Agriculture Organization, *State of the World's Forests 1999*, <http://www.fao.org/forestry/FO/SOFO/sofo_e.htm>, (accessed September 25, 1999).
World Resources Institute, 1997, *The Last Frontier Forests: Ecosystems and Economics on the Edge*, Forests Frontiers Initiative, Washington.

1. This section discusses the extraction and the first transformation of trees. Unless otherwise specified, the forest industries include the following industry groups: Logging; Forestry Services; Sawmill, Planing Mill and Shingle Mill Products, composed of the Sawmill and Planing Mill Products, and the Shingle and Shake industries; and Pulp and Paper, composed of the Pulp, Newsprint, Paperboard, Building Board, and Other Paper industries.
2. Kellog, R.S., 1923, *Pulpwood and Wood Pulp in North America*, McGraw-Hill, New York.
3. The timber trade was developed as a vital support to the naval fleet of Great Britain. The first forest policy in Canada intended to preserve large timber (mainly white pine) for masts for the Royal Navy. The first shipment left in 1634 and within a hundred years, the Royal Navy depended nearly totally on this source (Canadian Forest Service, 1997, *The State of Canada's Forests 1996-1997*, Natural Resources Canada, Ottawa).
4. Lower, A.R.M., 1938, *The North American Assault on the Canadian Forest: A History of the Lumber Trade between Canada and the United States*, The Ryerson Press, Toronto.
5. Canadian Forest Service, Natural Resources Canada, 1998, *National Forest Strategy 1998–2003, Sustainable Forests: A Canadian Commitment*, <http://www.nrcan.gc.ca/cfs/nfs/strateg/control_e.html>, (accessed September 27, 1999).
6. Statistics Canada, 1995, *Logging Industry*, Catalogue No. 25-201-XPB, Ottawa.
7. Provincial GDP figures do not allow the Sawmill, Planing Mill and Shingle Mill Products industries to disaggregate from the Wood Industries major group, as elsewhere in the text. The Wood Industries major group includes the following industry groups: Sawmill, Planing Mill and Shingle Mill Products; Veneer and Plywood; Sash, Door and Other Millwork; Wooden Box and Pallet; Coffin and Casket; and Other Wood Industries.
8. Statistics Canada, 1995, *Canadian Forestry Statistics*, Catalogue No. 25-202-XPB, Ottawa.
9. Provincial GDP figures do not allow the Pulp and Paper industries to disaggregate from the Paper and Allied Products major group, as elsewhere in the text. The Paper and Allied Products major group includes the following industry groups: Pulp and Paper; Asphalt Roofing; Paper Box and Bag; and Other Converted Paper Products.

Table 4.6.2
Gross Domestic Product of Selected Forest Products Industries, Selected Years

Year	Industries: Logging and Forestry Services	Industries: Sawmill, Planing Mill and Shingle Mill Products	Industries: Pulp and Paper	Industries: Total	Share of GDP: Logging and Forestry Services	Share of GDP: Sawmill, Planing Mill and Shingle Mill Products	Share of GDP: Pulp and Paper	Share of GDP: Total
	million 1992 dollars				percent			
1961	2 881	815	2 777	6 473	1.45	0.41	1.40	3.25
1971	3 469	1 393	3 317	8 179	1.05	0.42	1.00	2.47
1981	4 034	2 025	3 817	9 876	0.83	0.42	0.79	2.04
1991	3 959	2 698	3 869	10 526	0.66	0.45	0.64	1.75
1998	4 689	2 945	4 307	11 941	0.65	0.41	0.60	1.66

Source:
Statistics Canada, CANSIM, matrix 4677.

Table 4.6.3
Capital Expenditure in the Logging and Forestry Industries, 1960-69 to 1990-99

Decade	Construction	Machinery and equipment
	million dollars	
1960-69	255.9	281.9
1970-79	845.1	1 012.8
1980-89	1 156.4	1 207.3
1990-99	932.8	2 236.5

Sources:
Statistics Canada, Investment and Capital Stock Division.
Statistics Canada, CANSIM, matrix 11501.

Table 4.6.4
Employment in Selected Forest Products Industries, Selected Years

Year	Logging	Forestry Services	Sawmill, Planing Mill and Shingle Mill Products	Pulp and Paper	Total
	persons				
1985	52 006	14 242	49 952	81 248	197 448
1990	44 873	17 981	59 521	82 229	204 604
1995	48 636	19 637	57 594	65 142	191 009
1998	47 228	19 442	67 389	59 872	193 931

Source:
Statistics Canada, CANSIM, matrix 4285.

over $2 billion in each province in 1997. This represented 1.5% of Quebec's GDP and 0.8% of Ontario's. These industries were more important to New Brunswick's economy, where they represented 2.8% of the provincial GDP.[1]

4.6.2 Employment

Employment in the forest products industries increased quickly during the first half of the century. From 1926 to 1950, employment grew by 75% in wood operations and by 67% in each of the lumber and the pulp and paper industries. The number of lumberjacks peaked during the late 1940s and early 1950s, reaching 163 000 in 1951.[2]

Until that time, logging had been a labour-intensive activity. However, mechanization transformed harvesting methods, with the successive introduction of the chainsaw, skidder, bulldozer, forwarder and feller-buncher. From 1970 to 1979, the forest industry's investment in machinery and equipment soared to over $1 billion, and surpassed the $2 billion mark from 1990 to 1999 (Table 4.6.3).

By 1998, employment in logging operations had fallen 9% from its early 1980s level (Table 4.6.4). The Forestry Services Industry, however, increased employment by 37% during the same period. Three provinces accounted for most of the employment in the forest products industries in 1998 (Table 4.6.5): British Columbia (36.5%), Quebec (31.1%) and Ontario (15.5%). As a share of provincial employment, these industries were most important in New Brunswick (4.7%) and British Columbia (4.7%).

1. Figures are in 1992 dollars (Statistics Canada, 1998, *Provincial Gross Domestic Product by Industry, 1984–1997*, Catalogue No. 15-203-XPB, Ottawa).
2. Statistics Canada, 1983, *Historical Statistics of Canada, Second Edition*, F.H. Leacy (ed.), Catalogue No. 11-516E, Ottawa.

Table 4.6.5
Employment in Forest Products Industries[1] by Province, Selected Years

Year	Nfld.	P.E.I.	N.S.	N.B.	Que.	Ont.	Man.	Sask.	Alta.	B.C.	Total
	persons										
1985	1 459	x	6 363	11 477	57 752	41 091	2 374	1 293	5 985	66 836	194 630
1990	1 886	115	6 558	11 792	54 651	36 760	2 336	1 375	7 488	78 412	201 373
1995	1 842	x	3 808	12 004	54 647	29 205	870	1 019	7 943	72 243	183 581
1998	1 773	x	6 184	12 224	58 489	29 124	1 342	1 232	8 951	68 596	187 915

Note:
1. Includes the following industries: Logging; Forestry Services; Sawmill, Planing Mill and Shingle Mill Products; and Pulp and Paper.
Source:
Statistics Canada, CANSIM, matrices 4285, 4299, 4313, 4327, 4341, 4355, 4369, 4383, 4397, 4411, 4425, 4439 and 4453.

Table 4.6.6
Employment and Roundwood Harvest, Selected Years

Year	Employment	Roundwood harvested	
	persons	million m^3	m^3 per employee
1985	52 006	168.7	3 244.3
1990	44 873	162.6	3 613.0
1995	48 636	188.2	3 874.4
1997	48 742	188.9	3 875.7

Sources:
Canadian Council of Forest Ministers, 1998, *Compendium of Canadian Forestry Statistics 1997: National Forestry Database Program*, Canadian Forest Service, Natural Resources Canada, Ottawa.
Statistics Canada, CANSIM, matrix 4285.

4.6.3 Harvest

The employment decline in the Logging Industry would have been sharper had harvest levels remained constant. But the harvest of roundwood increased by 12% between 1985 and 1997. Each employee harvested an average 3 875.7 m^3 in 1997—a 19.5% increase in productivity since 1985 (Table 4.6.6).

Most roundwood harvested in Canada (82% in 1997) is composed of softwood species such as spruce, pine and fir. Roundwood is separated into logs and bolts, which are mainly used by the Sawmills, Planing Mill and Shingle Mill Products Industries, or pulpwood, destined for the Pulp and Paper Industries. In 1995, logs and bolts represented close to 85% of the value of softwood shipments (Table 4.6.7).

4.6.4 Exports

Canada is one of the world's largest exporters of forest products, accounting for almost 20% of the total value of the global forest products trade.[1] In 1998, for the eighth time in the past decade, the contribution of forest products resulted in a surplus of the trade balance.[2] Since 1978, exports of forest products have increased almost four-fold, reaching $35.8 billion in 1996 (Table 4.6.8). In 1997, Canada was the world's largest exporter of sawnwood and sleepers, wood pulp, paper (including newsprint) and paperboard (Table 4.6.9). These exports went mainly to the United States, but also to the European Union and Japan.

The United States is the primary client for Canada's forest products exports. Between 1950 and 1998, the value of Canadian pulpwood, lumber and wood pulp exports to the United States increased from $473.5 million to $12.5 billion annually (Table 4.6.10). Expressed as a share, the United States represented 88.8% of total Canadian forest products exports in 1950, but only 54.6% in 1990. In 1998, the U.S. share of forest products exports was 67.9%.

Trade disputes between Canada and the United States over forest products such as softwood lumber were part of the reason for the drop in American demand for Canadian forest products. The governments of Canada and the United States reached a five-year agreement to limit lumber exports by Canadian producers to the U.S. market. This agreement came into effect at the beginning of April 1996.[3]

1. Canadian Forest Service, 1997, *The State of Canada's Forests, 1996–1997*, Natural Resources Canada, Ottawa.
2. Canadian Forest Service, 1999, *The State of Canada's Forests, 1998–1999*, Natural Resources Canada, Ottawa.
3. Statistics Canada, 1995, *Logging Industry*, Catalogue No. 25-201-XPB, Ottawa.

Table 4.6.7
Shipments of Roundwood by Product and Region, 1994 and 1995

Year/Region	Logs and bolts		Pulpwood		Total	
	Softwood	Hardwood	Softwood	Hardwood	Softwood	Hardwood
	million dollars					
1994						
Atlantic provinces	x	x	x	x	511.9	x
Quebec	454.1	x	130.5	x	584.6	79.2
Ontario	330.4	32.8	200.5	62.8	530.9	95.6
Manitoba and Saskatchewan	x	x	x	x	88.8	x
Alberta	x	x	x	x	174.4	x
British Columbia						
Coast	1 801.8	x	55.2	x	1 857.0	x
Interior	1 633.5	x	63.4	x	1 696.9	x
Total	**4 614.2**	**87.8**	**830.4**	**201.1**	**5 444.6**	**288.9**
1995						
Atlantic provinces	201.5	x	365.7	x	567.2	x
Quebec	506.1	x	124.1	124.1	630.2	x
Ontario	337.6	x	217.7	73.7	555.3	x
Manitoba and Saskatchewan	x	x	x	x	89.9	x
Alberta	195.8	x	-	x	195.8	x
British Columbia						
Coast	1 892.2	x	85.5	x	1 977.7	x
Interior	x	x	x	x	1 882.4	x
Total	**4 993.4**	**x**	**905.6**	**232.1**	**5 899.0**	**x**

Source:
Statistics Canada, *Canadian Forestry Statistics*, Catalogue No. 25-202-XPB, Ottawa.

Table 4.6.8
Export of Forest Products, 1978-1996

Year	Logs and bolts	Pulpwood	Other primary forest products	Lumber	Wood chips	Veneer and plywood	Shingles and shakes	Wood pulp	Paper	Total	As share of Canadian exports
	million dollars										percent
1978	37.8	14.3	..	3 228.6	48.9	211.1	185.7	2 179.3	3 500.7	9 406.6	17.6
1979	58.3	15.5	..	3 911.0	53.5	247.7	191.7	3 077.8	4 044.4	11 600.0	17.7
1980	67.7	26.0	..	3 350.4	90.9	236.7	178.8	3 867.0	4 684.3	12 501.9	16.3
1981	54.3	24.7	..	2 989.7	97.8	221.4	170.4	3 820.3	5 287.4	12 666.0	15.0
1982	91.1	8.2	..	2 918.7	97.9	214.8	157.5	3 221.4	5 008.2	11 717.6	13.9
1983	137.0	11.5	..	3 964.5	89.3	257.0	231.1	3 048.7	4 985.8	12 724.9	14.1
1984	223.8	10.7	121.4	4 253.8	85.4	269.9	264.5	3 908.0	6 055.9	15 193.6	13.6
1985	163.6	8.4	121.4	4 595.3	83.2	246.5	257.4	3 393.8	6 654.9	15 524.4	13.0
1986	187.2	12.4	114.5	4 949.9	76.8	238.0	268.3	4 072.0	7 207.9	17 127.1	13.7
1987	317.2	21.6	124.2	5 858.6	73.4	265.9	217.4	5 473.0	7 677.8	20 029.3	15.2
1988	297.2	30.4	139.5	5 413.6	94.5	288.1	211.2	6 474.8	8 866.6	21 815.9	15.2
1989	189.6	21.5	210.7	5 516.0	164.7	284.2	214.8	6 940.3	8 505.9	22 047.7	15.0
1990	109.6	7.6	212.2	5 371.9	140.2	291.1	226.2	6 128.7	9 037.7	21 525.2	14.2
1991	96.0	3.4	180.0	5 150.7	112.1	254.2	211.4	4 937.3	9 085.0	20 030.1	13.6
1992	166.7	3.5	189.5	6 547.9	113.1	340.9	264.8	5 067.6	9 372.2	22 066.2	13.5
1993	185.4	8.4	195.1	9 451.1	103.4	411.4	267.4	4 640.8	10 105.6	25 368.6	13.3
1994	140.7	19.9	197.0	11 400.1	83.6	544.9	244.6	6 755.3	11 299.8	30 685.9	13.4
1995	111.2	35.3	230.2	10 940.3	93.0	716.0	248.8	10 933.9	15 713.3	39 022.0	14.7
1996	116.4	19.1	241.9	12 543.1	97.2	704.5	261.4	6 921.3	14 869.9	35 774.8	12.8

Note:
Figures may not add up to totals due to rounding.
Sources:
Statistics Canada, *Canadian Forestry Statistics*, Catalogue No. 25-202-XPB, Ottawa.
Statistics Canada, CANSIM, matrix 3685.

Table 4.6.9
Canada's World Ranking for the Production and Exports of Selected Forest Products, 1997

Product	Production: Rank	Production: As a share of world production	Exports: Rank	Exports: As a share of world production
		percent		percent
Sawn wood and ties	2	14.8	1	43.2
Wood pulp	2	15.3	1	31.3
Wood-based panels	3	7.3	2	16.0
Paper and paperboard	4	6.4	1	16.6

Source:
Food and Agriculture Organization of the United Nations, 1999, *Yearbook of Forest Products, 1993-97*, Rome.

4.6.5 Forest management

The primary objective of forest management is timber production, which is achieved through harvesting and regenerating areas that have been harvested or damaged by fire or insects. Forest management is composed of silviculture, fire and pest control, resource access and other management issues such as inventories, research and timber management. In 1996, Canadian governments spent over $1.2 billion, and industry close to $1.4 billion, on forest management (Figure 4.6.1).

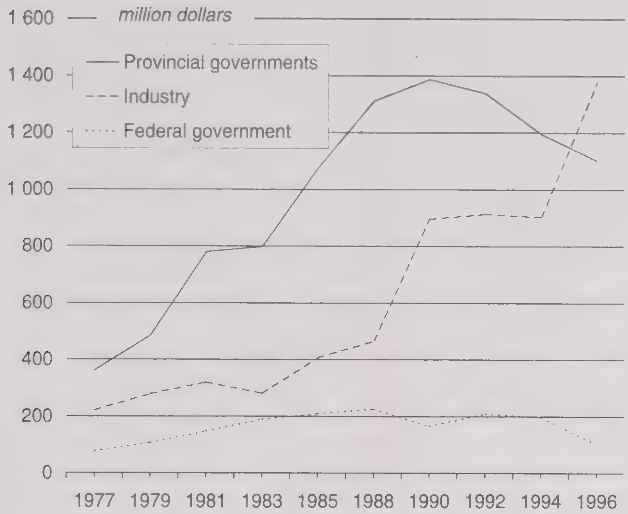
Differences in forest type and ownership mean that forest management practices vary across the nation (Text Box 4.6.2). Nonetheless, forestry activities on crown lands are conducted with sustained-yield management goals. Sustained-yield management means that timber is

Table 4.6.10
Exports of Pulpwood, Lumber and Wood Pulp to the United States, Selected Years

Year	Pulpwood: Total exports	Pulpwood: Exports to U.S.	Pulpwood: U.S. share of exports	Lumber: Total exports	Lumber: Exports to U.S.	Lumber: U.S. share of exports	Wood pulp: Total exports	Wood pulp: Exports to U.S.	Wood pulp: U.S. share of exports
	million dollars		percent	million dollars		percent	million dollars		percent
1950	33.6	32.8	97.6	291.1	249.7	85.8	208.6	191.0	91.6
1960	25.8	21.0	81.4	346.3	259.2	74.8	325.1	256.2	78.8
1970	26.8	13.9	51.9	663.8	458.7	69.1	785.2	485.4	61.8
1980	26.0	8.0	30.8	3 350.4	2 027.0	60.5	3 867.0	1 911.7	49.4
1990	7.6	0.8	10.5	5 371.9	3 213.7	59.8	6 128.7	3 071.8	50.1
1998	8.9	8.9	100.0	11 717.0	9 509.4	81.2	6 688.5	3 000.4	44.9

Sources:
Statistics Canada, 1983, *Historical Statistics of Canada, Second Edition*, F.H. Leacy (ed.), Catalogue No. 11-516E, Ottawa.
Statistics Canada, *Canadian International Merchandise Trade*, Catalogue No. 65-001-XPB, Ottawa.

Figure 4.6.1
Forest Management Expenditure by Source, Selected Years



Source:
Statistics Canada, CANSIM, matrix 6095.

Text Box 4.6.2
Ownership of Canadian Forests

Governments publicly own and oversee 94% of Canada's forests. Of these forests, 71% are under provincial jurisdiction while 23% are under federal jurisdiction. The remaining 6% are in the hands of an estimated 425 000 private landowners.

Private landowners may own just 6% of Canada's total forest land, but their forests are generally of high quality and productive. In fact, private owners hold 10% of all forest land capable of producing commercial timber. Privately owned forests are the source of 19% of all industrial roundwood harvested in the country. They are even more central to other forest products sectors, supplying 77% of Canada's maple syrup, 79% of all fuel wood and firewood, and virtually all of the nation's Christmas trees.

Sources:
Canadian Forest Service, 1999, *The State of Canada's Forests, 1998–1999*, Natural Resources Canada, Ottawa.
Canadian Forest Service, 1998, *The State of Canada's Forests, 1997–1998*, Natural Resources Canada, Ottawa.

not to be harvested at a rate that exceeds its capacity to regrow. The measure of the sustainable level of harvests, based on the area available for harvest and growth rate models, is known as the 'annual allowable cut' (See section 5.2–**Forest resources**).

The annual allowable cut is attained for the most part by clearcutting areas that have never been commercially logged before.[1] Clearcutting, also known as 'even-aged forest stand management,' has been the main method of harvesting in Canada since the introduction of heavy machinery.[2] Partial (selective) cutting methods are being promoted and investigated as alternatives where clear-cutting may have unacceptable impacts on wildlife habitat or water resources, for example.

1. May, E., 1999, *At the Cutting Edge: The Crisis in Canada's Forests*, Key Porter Books, Toronto.
2. Canadian Forest Service, 1997, *The State of Canada's Forests, 1996–1997*, Natural Resources Canada, Ottawa.

Forest management expenditures by governments are declining. The largest decrease involved silviculture spending, which has been cut by almost half since 1990 (Table 4.6.11). Overall, the greatest increase in forest management expenditure since 1977, has been for the 'other management expenditures' category, which comprises forest inventory, forest research and timber management (Figure 4.6.2).

Data for silvicultural practices exist from 1975. They indicate that between 1975 and 1997, 20.7 million hectares of forest had been harvested. In 1997, 2.7 million hectares were considered as understocked (not regenerating) and 12 million hectares as regenerating.[3]

3. Canadian Council of Forest Ministers, 1999, *National Forestry Database Program*, <http://www.nrcan.gc.ca/cfs/proj/iepb/nfdp>, (accessed September 28, 1999).

Table 4.6.11
Total Annual Expenditures on Forest Management by Activity and Source of Funding, 1990-1996

Year	Silviculture		Protection (fire and pest control)		Resource access		Other management expenditures	
	Government	Industry	Government	Industry	Government	Industry	Government	Industry
	thousand dollars							
1990	551 378	173 123	411 764	40 225	59 689	505 215	529 542	177 954
1991	570 985	231 570	409 398	47 669	46 396	516 453	630 828	201 304
1992	518 151	187 129	366 219	28 878	45 784	386 565	616 978	310 488
1993	483 473	182 320	308 014	30 035	64 076	384 878	635 603	305 366
1994	408 639	182 320	387 259	30 035	85 476	384 878	511 210	305 366
1995	429 749	379 982	468 837	41 061	105 044	530 595	564 420	420 875
1996	284 760	344 920	331 379	38 318	67 809	558 172	519 381	431 497

Sources:
Canadian Council of Forest Ministers, 1999, *National Forestry Database Program*, <http://www.nrcan.gc.ca/cfs/proj/iepb/nfdp>, (accessed September 28, 1999)
Statistics Canada, CANSIM, matrix 6097.

4.6.6 Forest-dependent communities

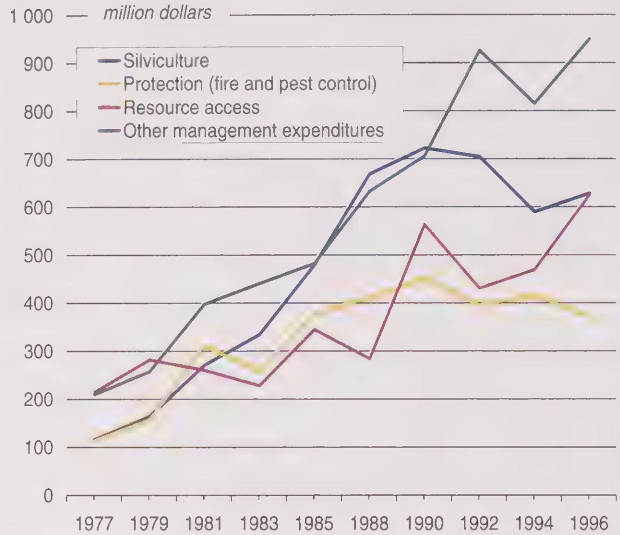
The main objective of forest management is to provide wood and fibre products to industry. But forest management also needs to ensure the sustainability of the environmental and social functions that the forest provides:[1] the health and vitality of forest-dependent communities is essential to achieve the sustainable development of Canadian forests.[2]

In Canada, 337 communities are considered heavily dependent on the forest. In each of these communities, employment income derived from forest products industries accounts for at least half of the community's income.[3] These communities are generally small, reliant on few industries, and more vulnerable to changes in their industries and local environment. Forest-dependent communities may be more unstable than larger urban areas, and this instability affects the social structure and the welfare of their residents. Larger forest-dependent communities tend to perform better economically than their smaller counterparts.[4]

In 1996, 945 674 people lived in forest-dependent communities, a 4.1% increase over 1986 (Table 4.6.12). Forest-dependent communities are more numerous in Quebec, although they represented a small share of the provincial population in 1996 (2.5%). The second-largest count of forest-dependent communities is found in British Columbia, but there they accounted for 13.9% of the province's population. The table shows that, between 1986 and 1996, the population living in forest-dependent communities increased in only two provinces, Alberta (23.0%) and British Columbia (15.5%). As illustrated on Map 4.6.1, there exists a clear divide between eastern Canada, characterized by small and decreasing forest-dependent communities, and western Canada, characterized by large, growing forest-dependent communities.

1. Canadian Council of Forest Ministers, 1997, *Criteria and Indicators of Sustainable Forest Management in Canada 1997*, Canadian Forest Service, Natural Resources Canada, Ottawa.
2. Canadian Forest Service, Natural Resources Canada, 1998, *National Forest Strategy 1998–2003, Sustainable Forests: A Canadian Commitment*, <http://www.nrcan.gc.ca/cfs/nfs/strateg/control_e.html>, (accessed October 21, 1999).
3. Williamson, T. and S. Annamraju, 1996, *Analysis of the Contribution of the Forest Industry to the Economic Base of Rural Communities in Canada*, Natural Resources Canada, Canadian Forest Service, Industry, Economics and Programs Branch, Working Paper No. 43, Ottawa.
4. Canadian Forest Service, 1998, *The State of Canada's Forests, 1996–1997*, Natural Resources Canada, Ottawa.

Figure 4.6.2
Forest Management Expenditure by Type, Selected Years



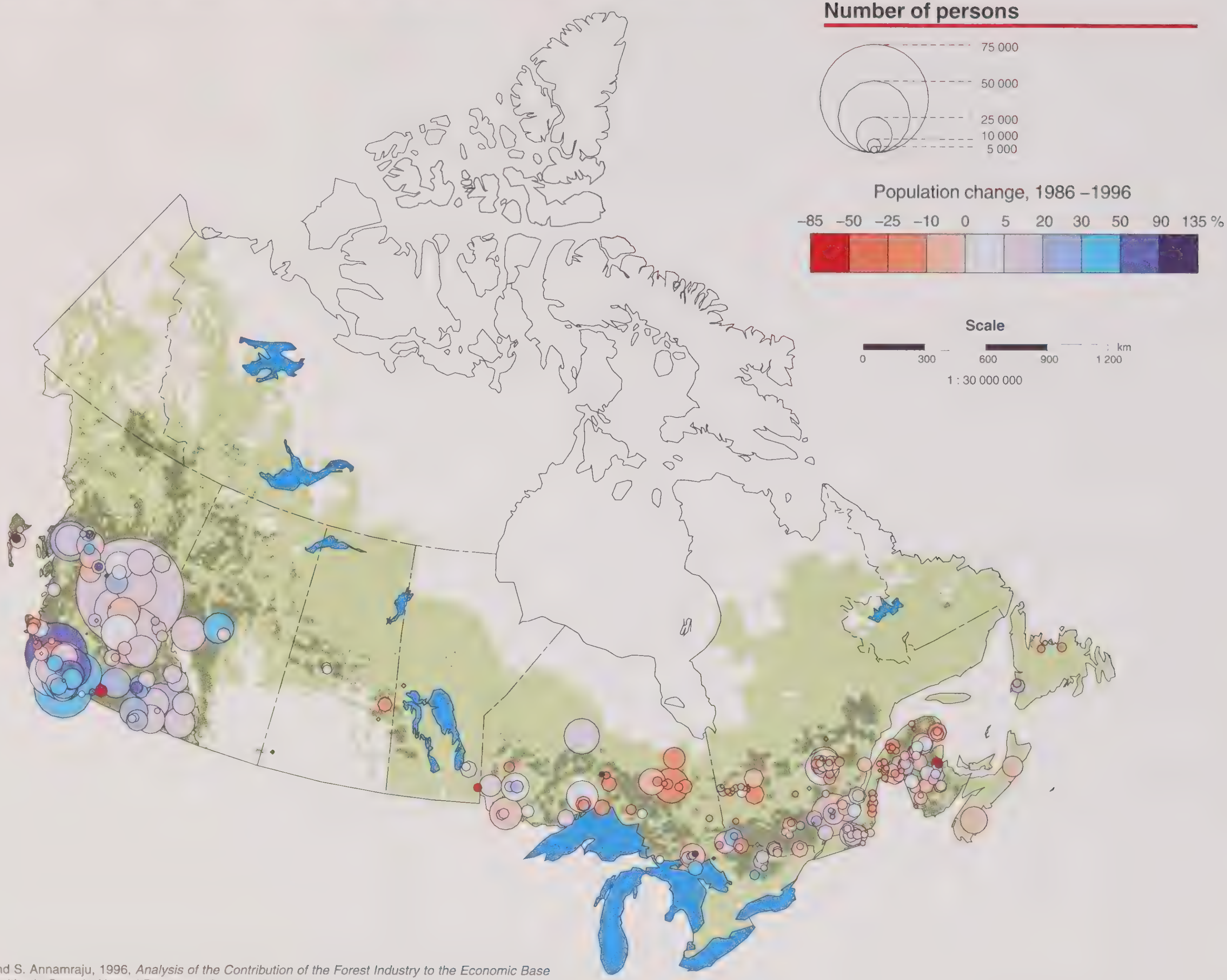
Sources:
Canadian Council of Forest Ministers, 1999, *National Forestry Database Program*, <http://www.nrcan.gc.ca/cfs/proj/iepb/nfdp>, (accessed September 28, 1999).
Statistics Canada, CANSIM, matrix 6097.

Table 4.6.12
Population in Forest-dependent Communities by Province, 1986, 1991 and 1996

Province	Communities	Population 1986	1991	1996	Change 1986-1996	1996 share of provincial population
	number	persons			percent	
Newfoundland	5	4 626	4 541	4 406	-4.8	0.8
Prince Edward Island	-	-	-	-	-	-
Nova Scotia	7	27 201	26 574	25 692	-5.5	2.8
New Brunswick	40	68 720	68 235	54 084	-21.3	7.3
Quebec	127	197 546	193 436	181 375	-8.2	2.5
Ontario	55	128 568	125 983	126 506	-1.6	1.2
Manitoba	5	11 016	11 024	10 171	-7.7	0.9
Saskatchewan	6	6 259	5 671	5 506	-12.0	0.6
Alberta	3	15 780	17 676	19 413	23.0	0.7
British Columbia	89	448 911	472 330	518 521	15.5	13.9
Total	**337**	**908 627**	**925 470**	**945 674**	**4.1**	**3.3**

Note:
Communities are considered forest-dependent when more than 49% of their income is derived from forest products industries.
Sources:
Williamson, T. and S. Annamraju, 1996, *Analysis of the Contribution of the Forest Industry to the Economic Base of Rural Communities in Canada*, Natural Resources Canada, Canadian Forest Service, Industry, Economics and Programs Branch, Working Paper No. 43, Ottawa.
Statistics Canada, Environment Accounts and Statistics Division.

Map 4.6.1
Population Size and Variation of Forest-dependent Communities, 1986-1996



Sources:
Williamson, T. and S. Annamraju, 1996, *Analysis of the Contribution of the Forest Industry to the Economic Base of Rural Communities in Canada*, Natural Resources Canada, Canadian Forest Service, Industry, Economics and Programs Branch, Working Paper No. 43, Ottawa.
Statistics Canada, Environment Accounts and Statistics Division.

4.7 Mineral industries

Mineral industries[1] have long occupied a significant economic position in Canada. Since the end of the Second World War, the discovery of important mineral assets has coincided with increasing demand from the growing world economy. Production of non-fuel minerals increased by a factor of 10 between 1948 and 1998 (Figure 4.7.1).

The value of mineral industries has more than doubled since 1961 (Table 4.7.1). Coal mining activities demonstrated the largest increase, while oil well activities (crude petroleum and natural gas) accounted for over half of all revenues of the mineral industries.

In 1997, mineral industries represented 19.4% of Alberta's Gross Domestic Product (GDP), 17% of the Northwest Territories' GDP, and 15.8% of Saskatchewan's GDP.[2] Prince Edward Island is the only province without mining and oil drilling activities.

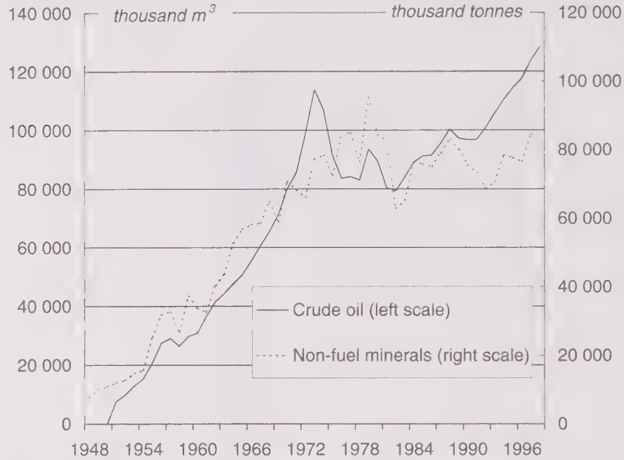
Employment

In 1998, 142 673 people were employed in the mineral industries—this represented 1.2% of total industrial employment in Canada.[3] Half of these employees worked in Alberta, where they made up 6% of industrial employment (Table 4.7.2). Employment in the crude oil and natural gas extraction industries has tripled since 1961 and now accounts for approximately a third of all employment in mineral extraction industries (Table 4.7.3).

The industries involved in the primary transformation of minerals (See Text Box 4.7.1) employed 68 054 people in 1997, down from a peak of 115 879 in 1981 (Table 4.7.4). The value of production, however, has increased, although it has not kept pace with GDP (Table 4.7.5). The production value of smelting non-ferrous metals doubled between 1961 and 1998, while the value of refining petroleum and coal products quadrupled in the same period.

1. Includes Mining, Quarrying and Oil Well Industries, and Service Industries Incidental to Mineral Extraction.
2. Statistics Canada, 1998, *Provincial Gross Domestic Product by Industry 1984–1997*, Catalogue No. 15-203-XPB, Ottawa.
3. Total industrial employment includes all industries except agriculture, fishing, trapping, private households, religious organizations and the military (Statistics Canada, CANSIM, matrix 4285).

Figure 4.7.1
Production of Selected Minerals, 1948-1998



Notes:
Minerals compiled in the non-fuel minerals are copper, nickel, lead, zinc, iron ore, gold, potash, salt, gypsum and cement.
Annual production of metallic minerals refers to the metal content of the ore mined, with the exception of iron ore, where the quantity of ore mined is the determining factor.
Sources:
Statistics Canada, CANSIM, matrices 9,13,14,19 and 20.
Statistics Canada, 1998, *Oil and Gas Extraction*, Catalogue No. 26-213-XPB, Ottawa

Transport

International shipping plays an important role in the mineral industries, accounting for 60% of the total tonnage loaded (Table 4.7.6). Coal and coke lead with 19.7% of all goods shipped, followed by iron ore at 17.5%. Mineral imports accounted for the largest share (74.5%) of total goods imported by ship. Crude petroleum accounted for 32.2% of all goods unloaded from international shipping.

Table 4.7.1
GDP at Factor Cost for Mineral Industries, Selected Years

Year	Metal mines	Non-metal mines (except coal)	Coal mines	Crude petroleum and natural gas	Quarries and sand pits	Services incidental to mineral industries	Total mineral industries[1]	Mineral industries as share of GDP
	millions of dollars							percent
1961	3 670	512	132	5 435	292	619	10 269	5.2
1966	3 932	858	137	8 623	548	783	13 473	5.0
1971	4 339	1 102	234	14 472	581	778	18 020	5.4
1976	4 431	1 192	233	12 906	557	1 182	17 926	4.3
1981	3 407	1 358	439	9 299	590	2 757	17 061	3.5
1986	4 278	1 183	773	10 918	809	2 263	19 742	3.6
1991	5 187	1 206	1 020	12 648	563	2 079	22 406	3.7
1996	4 606	1 258	1 048	16 530	693	2 702	26 837	4.0
1998	4 482	1 350	1 008	17 628	816	2 574	27 858	3.9

Notes:
Including milling and quarrying.
1.The total is not equal to the sum of the components until 1991. This is caused by changing the set of relative prices when a new base year is adopted.
Source:
Statistics Canada, CANSIM, matrix 4677.

Table 4.7.2
Employment in Mining, Quarrying and Oil Well Industries by Province and Territory, 1983-1998

Year	Nfld.	P.E.I.	N.S.	N.B.	Que.	Ont.	Man.	Sask.	Alta.	B.C.	Y.T.	N.W.T.	Canada
							persons						
1983	3 616	..	5 072	2 840	17 215	29 556	4 671	8 707	69 029	14 160	..	..	**158 130**
1984	3 687	..	4 385	2 826	18 020	29 257	4 913	9 831	72 476	14 493	..	..	**163 471**
1985	3 187	..	4 531	3 131	18 105	27 950	4 818	10 386	78 120	15 274	..	..	**169 035**
1986	2 728	..	4 801	3 048	17 171	26 713	4 106	9 884	71 362	14 777	..	..	**157 715**
1987	2 912	..	4 994	3 268	17 226	28 200	4 057	9 010	69 884	14 882	..	..	**157 644**
1988	3 256	..	4 879	3 296	17 261	30 446	4 213	8 889	73 013	15 556	..	..	**164 277**
1989	3 517	..	3 918	3 311	17 099	29 683	4 643	8 779	71 829	14 958	..	..	**160 820**
1990	3 461	..	4 181	2 705	17 547	27 595	4 549	8 423	71 369	15 011	..	..	**157 690**
1991	2 828	..	4 216	2 708	16 095	22 508	4 141	7 559	74 211	14 411	..	..	**151 031**
1992	2 378	..	3 648	2 830	14 848	20 613	4 073	7 315	63 918	10 990	..	..	**133 057**
1993	2 499	..	3 361	2 615	13 156	21 556	3 832	7 367	59 121	9 278	..	..	**124 758**
1994	2 784	..	3 686	2 584	14 711	19 598	3 569	7 479	70 048	10 658	..	..	**137 053**
1995	2 506	..	3 473	3 141	13 951	20 966	3 352	8 940	64 017	12 011	..	..	**134 379**
1996	2 621	..	2 818	3 236	13 273	21 103	2 879	9 194	61 670	11 783	..	..	**131 239**
1997	2 818	..	3 090	3 206	15 467	21 179	3 902	10 140	68 080	12 674	..	1 863	**143 404**
1998	3 080	..	2 627	3 142	15 116	18 693	3 814	9 849	71 635	12 621	..	1 334	**142 673**

Note:
Data do not add up to Canada total because of unavailable data for some provinces or territories.
Source:
Statistics Canada, CANSIM, matrices 4285, 4299, 4313, 4327, 4341, 4355, 4369, 4383, 4397, 4411, 4425, 4439 and 4453.

Table 4.7.3
Employment in Mineral Industries by Industry, Selected Years

Year	Metal mines	Non-metal mines	Structural materials	Coal	Crude oil and natural gas	Total non-fuel and fuel mineral industries
			persons			
1961	58 591	11 003	5 235	10 302	11 184	96 315
1971	66 012	15 105	5 328	8 069	15 896	110 410
1981	68 712	16 391	4 183	11 182	28 783	129 251
1991	42 092	10 812	5 026	10 817	31 450	100 197
1997[1]	37 165	11 676	6 537	8 996	36 033	100 407

Notes:
Data exclude employment in services incidental to mineral industries.
1. Forecast.
Source:
Natural Resources Canada, 1997, "Statistical Report," in *Canadian Minerals Yearbook: Review and Outlook*, <http://www.nrcan.gc.ca/mms/cmy/CMY_E3.html>, (accessed August 30, 1999), Minerals and Metals Sector, Ottawa, pp. 64.01-64.51.

Table 4.7.4
Employment in Smelting, Milling and Refining Activities of the Mineral Industries, Selected Years

Year	Non-ferrous metal	Iron and steel	Petroleum and coal	Total
		persons		
1961	29 938	34 749	10 660	75 347
1971	36 445	49 601	14 506	100 552
1981	38 011	56 543	21 325	115 879
1991	28 817	38 126	12 459	79 402
1997[1]	26 650	32 463	8 942[2]	68 054

Notes:
1. Forecast.
2. Prorated.
Source:
Natural Resources Canada, 1997, "Statistical Report," in *Canadian Minerals Yearbook: Review and Outlook*, <http://www.nrcan.gc.ca/mms/cmy/CMY_E3.html>, (accessed August 30, 1999), Minerals and Metals Sector, Ottawa, pp. 64.01-64.51.

Table 4.7.5
GDP at Factor Cost for Smelting, Milling and Refining Activities of the Mineral Industries, Selected Years

Year	Non-ferrous metal	Iron and steel	Petroleum and coal	Total as a share of GDP
	million dollars			percent
1961	838	1 223	324	1.20
1971	948	2 265	533	1.13
1981	1 024	2 405	793	0.87
1991	1 753	1 836	966	0.76
1998	1 764	2 476	1 185	0.76

Source:
Statistics Canada, CANSIM, matrix 4677.

Text Box 4.7.1
Mineral Processing

Usually, only a very small percentage of the ore removed from a non-ferrous metal mine is valuable mineral. The mined ore is concentrated by separating the valuable mineral from waste rock at the mine site, and the concentrate is transported to a smelter for further processing.[1] In the concentration process, the rock is first ground into particles fine enough to isolate the mineral. Some of the ways in which the mineral can then be removed are by dissolving it (gold, which exists as particles of metal, can be dissolved in cyanide and recovered from the solution), by magnetic attraction (some iron ores), or by a flotation process which separates the different types of rock suspended in water.

The copper, lead, nickel and zinc ores that are mined in Canada are sulphides, in which the metal is chemically bonded with sulphur. These ores are often found in combination and deposits usually contain other sulphides, such as pyrite. Gold and silver, which usually occur as pure (native) metal, are also usually found in association with sulphides. The sulphides present in mine waste react with air and water to form acid. The production of acidic effluent is known as 'acid mine drainage' and is the most serious environmental problem facing the mining industry.

Source:
Environment Canada, 1996, *The State of Canada's Environment 1996*, pp. 11-58, Ottawa.

1. Gold is an exception. The concentrate is pure metal (rather than ore in which the metal is bonded with another element), and relatively small in quantity. It can be refined in a furnace at the mine site.

Domestically, 20.5 million tonnes of minerals were shipped, representing 44% of all goods shipped within Canada (Table 4.7.7). The single most important mineral in this case is iron ore and concentrates. For the most part, iron ore travelled from ports in the St. Lawrence to the Great Lakes.

4.7.1 Non-fuel minerals[1]

Metallic minerals

Canada produces more than 30 metallic minerals. Five of these—copper, gold, iron ore, nickel and zinc—accounted for 85% of the total value of metal mining production in 1997 (Table 4.7.8).

1. Production figures for non-fuel minerals will be found in Table 5.7.3 of section 5.7–**Mineral resources**.

Table 4.7.6
International Shipping of Minerals, 1997

Mineral	Loaded		Unloaded	
	Quantity	As a share of total goods	Quantity	As a share of total goods
	million tonnes	percent	million tonnes	percent
Metallic minerals[1]				
Iron ore	32.9	17.5	8.0	8.4
Aluminum	0.6	0.3	6.4	6.7
Other	3.5	1.9	2.3	2.4
Total	**37.0**	**19.7**	**16.7**	**17.6**
Non-Metallic minerals				
Salt	3.5	1.9	1.1	1.2
Limestone	2.7	1.4	3.1	3.3
Sand and gravel	1.5	0.8	0.8	0.8
Gypsum	6.2	3.3	0.5	0.5
Potash	6.1	3.2	-	-
Sulphur	5.5	2.9	--	--
Other	4.9	2.6	1.8	1.9
Total	**30.4**	**16.2**	**7.3**	**7.7**
Mineral fuels				
Coal and coke	37.1	19.7	16.1	17.0
Crude petroleum	8.3	4.4	30.6	32.2
Total	**45.4**	**24.1**	**46.7**	**49.2**
Total minerals	**112.8**	**60.0**	**70.7**	**74.5**
Total goods	**188.1**	**100.0**	**94.9**	**100.0**

Note:
1. Includes concentrates.
Source:
Statistics Canada, 1997, *Shipping in Canada*, Catalogue No. 54-205-XPB, Ottawa.

Copper[2]

Large-scale copper mining began at Noranda, Quebec in the late 1920s. Production of copper nearly quadrupled in the period from 1948 to 1973 as new mines were developed. The volume of production of copper has declined 17% since then. In 1998, production was 689 000 tonnes.

The major copper producers are Ontario, British Columbia and Quebec, which together accounted for close to 90% of production in 1997 (Table 4.7.8). A large amount of copper concentrate is exported, especially to Japan, and both concentrate and scrap are imported in significant quantities for refining.

Gold[3]

Gold was discovered in British Columbia in the 1850s, in the Yukon Territory in 1869 and in northern Ontario in 1903. Canada is now the world's fourth-largest gold producer, accounting for about 7% of world production. At 164 tonnes, production in 1998 was not far below the historical peak of 167 tonnes produced in 1991.

2. Bokovay, G., 1997, "Copper," in Natural Resources Canada, *Canadian Minerals Yearbook: Review and Outlook*, "Mineral and Metal Commodity Reviews," <http://www.nrcan.gc.ca/mms/cmy/CMY_E3.html>, (accessed August 17, 1999), Minerals and Metals Sector, Ottawa, pp. 21.1–21.24.
3. Couturier, G., 1998, "Gold," in Natural Resources Canada, *Canadian Minerals Yearbook: Review and Outlook*, "Mineral and Metal Commodity Reviews," <http://www.nrcan.gc.ca/mms/cmy/CMY_E3.html>, (accessed August 17, 1999), Minerals and Metals Sector, Ottawa, pp. 23.1–23.16.

Table 4.7.7
Domestic Shipping of Minerals, 1997

Mineral	Loaded				Unloaded				Total
	Atlantic	St. Lawrence	Great Lakes	Pacific	Atlantic	St. Lawrence	Great Lakes	Pacific	
	thousand tonnes								
Metallic minerals[1]									
Iron ore	-	5 711.8	-	-	-	1 410.1	4 301.7	-	5 711.8
Aluminum ore	-	257.1	-	-	-	236.4	20.7	-	257.1
Other ores	1.7	2 658.6	271.1	-	3.4	2 585.8	342.2	-	2 931.3
Total	**1.7**	**8 627.6**	**271.1**	**-**	**3.4**	**4 232.3**	**4 664.6**	**-**	**8 900.3**
Nonmetallic minerals									
Salt	1 026.7	-	2 021.4	-	266.2	1 451.8	1 330.2	-	3 048.2
Limestone	395.4	23.5	1 770.4	647.2	23.5	395.4	1 770.4	647.2	2 836.5
Sand and gravel	76.8	-	296.4	1 019.9	76.8	44.1	252.4	1 019.9	1 393.1
Gypsum	778.5	-	-	73.1	162.4	348.4	267.8	73.1	851.7
Potash	-	-	67.3	-	-	29.0	38.3	-	67.3
Sulphur	-	-	-	8.3	-	-	-	8.3	8.3
Other	256.0	184.2	2 347.9	104.2	211.6	522.2	2 054.2	104.2	2 892.3
Total	**2 533.4**	**207.7**	**6 503.5**	**1 852.8**	**740.4**	**2 790.9**	**5 713.3**	**1 852.8**	**11 097.3**
Mineral fuels									
Coal and coke	-	-	523.8	-	-	58.9	464.9	-	523.8
Crude petroleum	24.1	-	-	-	11.1	13.0	-	-	24.1
Total	**24.1**	**-**	**523.8**	**-**	**11.1**	**71.9**	**464.9**	**-**	**547.9**
Total minerals	**2 559.2**	**8 835.2**	**7 298.3**	**1 852.8**	**754.9**	**7 095.1**	**10 842.8**	**1 852.8**	**20 545.6**
Total all goods	**6 101.1**	**11 572.0**	**16 998.1**	**12 037.5**	**4 955.4**	**15 597.5**	**14 118.3**	**12 037.5**	**46 708.8**
Minerals as a share of total goods (percent)	**42.0**	**76.0**	**43.0**	**15.0**	**15.0**	**45.0**	**77.0**	**15.0**	**44.0**

Note:
1. Includes concentrates.
Source:
Statistics Canada, 1997, *Shipping in Canada*, Catalogue No. 54-205-XPB, Ottawa.

Gold is produced in all but three provinces (Table 4.7.8). The largest producers are Ontario and Quebec, which respectively accounted for 46.7% and 22.2% of total value in 1997.

Iron ore[1]

Most of Canada's iron ore production (96%) comes from three mining operations in northern Quebec and Labrador. Production began in the 1950s with the construction of two railways to the ports of Sept-Îles and Port Cartier. In 1998, Canada's iron ore production was 39 million tonnes, compared to 60 million tonnes in 1979. In 1997, over 32 million tonnes was exported, more than half to European countries and a third to the United States.

Nickel[2]

Nickel was first discovered in Sudbury in 1883. Nickel production, mined solely in Ontario and Manitoba, more than doubled between 1950 and 1970. In 1997, production value reached almost $1.8 billion (Table 4.7.8).

Domestic consumption of nickel is equivalent to only 12% of mine production. Most of the nickel is exported as refined metal, although 40% of mine production is exported as matte (smelter output) for refining in Norway and the United Kingdom. Matte is also imported for refining, primarily from Cuba.

Zinc[3]

Mine production of zinc increased rapidly in the mid-1960s, tripling between 1963 and 1970. The level of production has been maintained since then, with New Brunswick being the largest producer (Table 4.7.8). Almost half of the ore is exported, mainly to European countries. Ore is imported as well, and an amount equivalent to about 70% of annual mine output is refined.

1. Miron, M., 1998, "Iron Ore," in Natural Resources Canada, *Canadian Minerals Yearbook: Review and Outlook*, "Mineral and Metal Commodity Reviews," <http://www.nrcan.gc.ca/mms/cmy/CMY_E3.html>, (accessed August 17, 1999), Minerals and Metals Sector, Ottawa, pp. 27.1–27.5.
2. McCutcheon, B., 1998, "Nickel," in Natural Resources Canada, *Canadian Minerals Yearbook: Review and Outlook*, "Mineral and Metal Commodity Reviews," <http://www.nrcan.gc.ca/mms/cmy/CMY_E3.html>, (accessed August 17, 1999), Minerals and Metals Sector, Ottawa, pp. 37.1–37.22.
3. Chevalier, P., 1998, "Zinc," in Natural Resources Canada, *Canadian Minerals Yearbook: Review and Outlook*, "Mineral and Metal Commodity Reviews," <http://www.nrcan.gc.ca/mms/cmy/CMY_E3.html>, (accessed August 17, 1999), Minerals and Metals Sector, Ottawa, pp. 62.1–62.18.

Table 4.7.8
Production of Leading Minerals by Province and Territory, 1997

	Selected metallic minerals					Mineral fuels			Other minerals		Total production		
Province/Territory	Copper	Gold	Iron ore	Nickel	Zinc	Coal	Crude petroleum	Natural gas[1]	Potash	Sand and gravel	Metals	Fuels	Others
							million dollars						
Newfoundland	1	43	883	-	-	-	29	-	-	10	928	29	41
Prince Edward Island	-	-	-	-	-	-	-	-	-	1	-	-	4
Nova Scotia	-	-	-	-	-	152	120	-	-	16	-	273	215
New Brunswick	42	3	-	-	498	18	-	-	x	x	661	18	258
Quebec	403	556	x	-	335	-	-	-	-	72	2 193	-	1 120
Ontario	752	1 171	x	1 335	213	-	41	38	-	329	3 834	79	1 618
Manitoba	165	120	-	442	149	-	104	-	-	x	945	104	79
Saskatchewan	-	61	-	-	-	123	2 888	367	x	x	620	3 378	1 422
Alberta	-	-	-	-	-	517	14 214	11 185	-	134	-	25 917	468
British Columbia	702	256	2	-	299	1 119	498	1 037	-	152	1 505	2 655	463
Yukon Territory	-	101	-	-	71	-	-	24	-	3	204	24	3
Northwest Territories	-	200	-	-	310	-	235	10	-	6	535	246	7
Canada	**2 065**	**2 510**	**1 431**	**1 777**	**1 875**	**1 929**	**18 130**	**12 661**	**1 466**	**801**	**11 426**	**32 721**	**5 696**

Notes:
Preliminary data.
Figures may not add up to totals due to rounding.
1. Includes natural gas by-products.
Source:
Natural Resources Canada, 1998, *1997 Canadian Minerals Yearbook*, Ottawa.

Non-metallic minerals

Potash[1]

The principal non-metallic mineral mined in Canada is potash. In 1997, it represented over half of non-metallic mineral production value.[2] Canada is the world's principal producer of potash, which is primarily used as a fertilizer.

The Canadian potash industry first developed in the early 1960s in Saskatchewan, where more than 90% of production was still concentrated in 1998. Canada produced 9 million tonnes in 1998, or 35% of world output. Canada exports potash to about 35 countries; most exports are destined for the United States (60%) and Asia (25%).

4.7.2 Mineral fuels[3]

Coal

Coal mining on a large scale started in the Maritimes in 1826. Production and consumption of coal increased until 1950 when other energy sources began to supplant coal as a fuel for heating buildings or powering ships and railway locomotives. Domestic production during this period met no more than half the demand.

However, in the mid-1960s, coal consumption increased again and has grown by a factor of eight since then. In 1997, coal was used mainly to produce electricity (49.5 million tonnes), steel (4.5 million tonnes) and cement (2 million tonnes).

By 1997, the volume of production in Alberta and Saskatchewan had increased five-fold over 1951, while production in British Columbia had increased 17 times. Seventy-two percent of Alberta's production and 85% of Saskatchewan's production were used in these provinces to generate electricity, whereas most of the coal produced in British Columbia was exported. Canadian exports of coal reached 36 million tonnes in 1997, much of it to Japan (50%) and Korea (17%). About 16 million tonnes of coal was imported, most of it by Ontario from the United States.

Crude petroleum

The first successful oil well was drilled in southwestern Ontario in 1858, reaching oil below asphalt beds that were already exploited commercially at the site.[4] Many others soon followed in an oil boom based mainly on the demand for kerosene for lighting. The introduction of automobiles by the end of the century created an increasing demand for gasoline. The first oil well in western Canada was completed in 1902, but development of the industry was relatively slow until a new era began with the discovery of large oil fields in Alberta in the late 1940s and 1950s. Large fields of natural gas were also discovered at this time.

1. Prud'homme, M., 1998, "Potash," in Natural Resources Canada, *Canadian Minerals Yearbook: Review and Outlook*, "Mineral and Metal Commodity Reviews," <http://www.nrcan.gc.ca/mms/cmy/CMY_E3.html>, (accessed August 17, 1999), Minerals and Metals Sector, Ottawa, pp. 41.1–41.15.
2. Statistics Canada, 1997, *Canada's Mineral Production, Preliminary Estimates*, Catalogue No. 26-202-XIB, Ottawa.
3. See section 5.6–**Energy resources** for a detailed discussion on energy reserves, production, consumption and management.

4. The 15-metre well was drilled at Black Creek by James Williams and Charles Tripp. The 'first' is often attributed to E.L. Drake, Pennsylvania, 1859 (Petroleum Communication Foundation, 1989, *Our Petroleum Challenge*, Calgary).

Table 4.7.9
Mineral Fuels Production, Selected Years

Year	Fuel minerals		
	Coal	Crude oil and equivalent	Natural gas
	thousand tonnes	thousand m^3	
1951	16 859	7 644	-
1961	9 434	36 486	16 595 000
1971	16 723	85 605	60 217 900
1981	40 082	80 329	67 943 800
1991	71 135	96 748	105 246 200
1998	75 079	128 400	160 514 400

Note:
Annual production of metallic minerals refers to the metal content of the ore mined, with the exception of iron ore, where the quantity of ore mined is the determining factor.
Sources:
Statistics Canada, *Coal and Coke Statistics*, Catalogue No.45-002-XPB, Ottawa.
Statistics Canada, 1998, *Oil and Gas Extraction 1997*, Catalogue No. 26-213-XPB, Ottawa.

These discoveries justified the construction of long distance pipelines. In 1953, pipelines from Edmonton, Alberta, carrying oil to Sarnia, Ontario, and gas to Vancouver, British Columbia, were completed. A gas pipeline to eastern Canada was completed in 1958. Large-scale expansion of natural gas production started in the 1960s after the completion of gas pipeline systems across Canada and the start of exports to the United States.

In 1998, production of crude oil reached 128.4 million m^3 (Table 4.7.9), of which 77.4 million m^3 were exported. Production of natural gas reached 160.5 billion m^3 with exports of 89.4 million m^3. The value of by-products of refining natural gas—propane, butane, ethane and sulphur—was also significant at about 25% of the value of the natural gas produced. Canada is the world's second-largest producer of sulphur (much of it is used to produce fertilizers) and most of the sulphur is obtained from the production of natural gas.[1]

4.7.3 Exploration[2]

Expenditures on mineral exploration declined during the 1980s, although expenditures on exploration for gold increased markedly, peaking in the late 1980s. By 1992, exploration expenditures had fallen to a 25-year low. Exploration expenditures started increasing again in 1993, stimulated by price increases in metals and discoveries of diamonds.[3] Expenditures reached $895 million in 1996 (Table 4.7.10).[4] Since 1994, exploration activity has been relatively successful, with a discovery rate comparable to the 1970s.[5]

Table 4.7.10
Mineral Exploration Expenditures by Province and Territory, 1994-1998

Province/Territory	1994	1995	1996	1997[1]	1998[2]
	millions of dollars				
Newfoundland	12.4	71.1	92.5	69.0	46.0
Prince Edward Island	-	-	-	-	-
Nova Scotia	1.7	3.0	6.9	9.0	9.1
New Brunswick	10.0	12.7	14.8	12.2	8.4
Quebec	130.3	123.3	137.2	140.3	153.6
Ontario	113.0	129.7	194.9	173.9	132.7
Manitoba	40.5	32.6	41.2	39.3	42.1
Saskatchewan	50.6	43.8	50.6	55.5	46.2
Alberta	9.4	10.6	10.8	19.1	33.0
British Columbia	85.0	79.4	104.9	96.8	103.1
Yukon Territory	25.7	39.3	46.4	37.2	36.8
Northwest Territories	149.5	172.1	194.5	151.9	156.4
Total	**628.1**	**717.6**	**894.7**	**804.2**	**767.4**

Notes:
Figures may not add up to totals due to rounding.
1. Preliminary estimate.
2. Forecast.
Source:
Natural Resources Canada, 1998, "Mineral Exploration Expenditures in Canada" in *Canadian Minerals Yearbook*, <http://www.nrcan.gc.ca/mms/cmy/CMY_E3.html>, (accessed August 17, 1999), Ottawa, pp.1-13.

Indicative of the importance of continuing exploration and development activity in the mineral fuels sector, a record 18 100 oil and gas wells were drilled in 1997. Production began at Hibernia, an offshore crude oil facility located off the coast of Newfoundland. The production of crude petroleum from the large oil sands deposits in northern Alberta, which began in the 1960s, accounted for 25% of Canada's total output in 1997.[6]

1. Statistics Canada, 1998, *Oil and Gas Extraction*, Catalogue No. 26-213-XPB, Ottawa.
2. Bouchard, G., 1997, "Mineral Exploration Activity in Canada," in Natural Resources Canada, *Canadian Minerals Yearbook*, <http://www.nrcan.gc.ca/mms/cmy/CMY_E3.html>, (accessed August 17, 1999), Minerals and Metals Sector, Ottawa, pp. 3.1–3.22.
3. Canada's first diamond mine, located in the Northwest Territories, opened in 1998 [Natural Resources Canada, *Northwest Territories Mining Facts*, <http://nrn1.nrcan.gc.ca/ms/efab/mmsd/facts/nwt.htm>, (accessed November 18, 1999), Minerals and Metals Sector, Ottawa].
4. Nickel, copper and lead prices increased by 60% and zinc by 14% between 1993 and 1995, although these prices have not been maintained since then.
5. Cranstone, D., 1997, "Canadian Mineral Exploration and Discovery Analysis," in Natural Resources Canada, *Canadian Minerals Yearbook*, <http://www.nrcan.gc.ca/mms/cmy/CMY_E2.html>, (accessed August 17, 1999), Minerals and Metals Sector, Ottawa, pp. 4.1–4.12.
6. Statistics Canada, 1998, *Oil and Gas Extraction*, Catalogue No. 26-213-XPB, Ottawa.

4.8 Transportation

Ground, sea and air transportation are essential to the economy because they bring our goods to market and get people from place to place. In 1996, the Canadian transportation industry moved 838 million tonnes of goods[1] and 1.4 billion passengers.[2] In 1997, this industry yielded 3.9% of Canada's Gross Domestic Product (GDP)[3] and generated 450 800 direct jobs.[4] However, trucking is the only form of transport that has expanded in its GDP percentage over the past two decades (Figure 4.8.1). On the 1996 Census, more than 222 000 men reported they were truck drivers. This was the most common job among men.[5]

4.8.1 The transportation industry

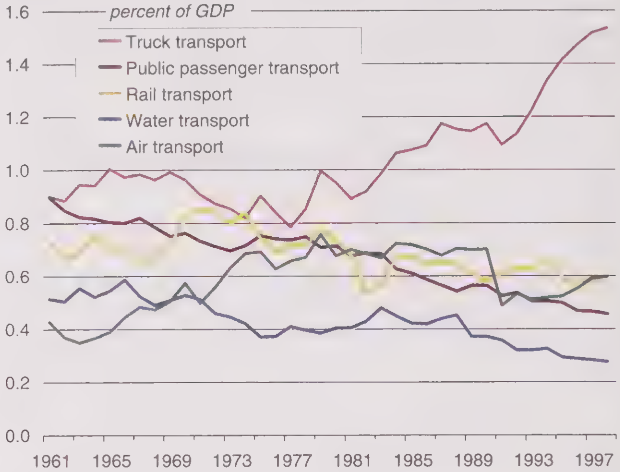
The transportation industry may be divided into three major areas of activity: transport of goods, commercial passenger transport and private transport.

Transport of goods

Maritime[6] and rail transport were the modes of transportation that carried the most tonnage. In 1996, maritime transport moved 309 million tonnes and rail moved 299 million tonnes of goods (tables 4.8.1 and 4.8.2). Such dominance can be explained by the fact that bulk goods like coal, grain, crude oil and lumber are shipped primarily by these two means of transportation.

Trucking took third place, transporting 229 million tonnes in 1996 (Table 4.8.3). Trucking has experienced the sharpest growth of any mode of transportation since the early 1990s (Figure 4.8.2). Air transport, meanwhile, remained marginal. It served to transport high unit-value goods (Table 4.8.4).

Figure 4.8.1
Evolution of GDP Contribution by Transport Mode, 1961-1998



Source:
Statistics Canada, CANSIM, matrix 4677.

1. Tonnage shipped is the total weight of freight shipped by all means of transportation combined. Freight travelling intermodally might be counted for each means of transportation used, resulting in multiple counts of the same tonnage.
2. The estimate of the number of passengers transported excludes the transportation of school children and individuals by private cars.
3. Statistics Canada, CANSIM, matrix 4677.
4. Statistics Canada, 1999, *Annual Estimates of Employment, Earnings and Hours*, 1986–1998, Catalogue No. 72F0002XIB, Ottawa.
5. Statistics Canada, Census of Population.

6. Since maritime transport figures take Canadian port activities into account, the shipped tonnage of domestic goods is counted twice: at the port of loading and at the unloading port. Net tonnage transported is calculated by adding the international tonnage handled in Canadian ports to the tonnage loaded at these same ports.

Table 4.8.1
Water Transport, 1988-1997

Year	Freight loaded		Freight unloaded		Net tonnage	Containerized freight		Movement of freight	Passengers transported
	Domestic	International	Domestic	International		Domestic	International		
	tonnes							tonne-kilometres	passenger-kilometres
	millions								
1988	70.0	171.0	70.0	78.0	320.0	1.0	12.0	1 535 266	30.0
1989	62.0	159.0	62.0	80.0	301.0	1.0	12.0	1 440 266	31.0
1990	60.0	159.0	60.0	73.0	292.0	1.0	12.0	1 601 718	33.0
1991	57.0	168.0	57.0	66.0	292.0	0.0	12.0	1 696 465	33.0
1992	52.0	153.0	52.0	69.0	275.0	1.0	12.0	1 567 265	32.0
1993	50.0	152.0	50.0	71.0	274.0	0.0	13.0	1 551 651	34.0
1994	52.0	170.0	52.0	76.0	299.0	0.0	14.0	1 690 730	34.0
1995	50.0	176.0	50.0	83.0	310.0	0.0	15.0	1 758 259	37.0
1996	48.0	174.0	48.0	85.0	308.0	0.0	17.0	..	..
1997	46.0	188.0	46.0	94.0	329.0	0.0	19.0	..	..

Source:
Statistics Canada, *Shipping in Canada*, Catalogue No. 54-205-XPB, Ottawa.

Table 4.8.2
Rail Transport, 1961-1996

Year	Freight movement		Passenger movement		Locomotives	Passenger cars	Freight cars	Fuel consumed[1]	Track operated[2]
	tonnes	tonne-km	passengers						
	millions				number			million litres	kilometres
1961	276.4	96 108	18.8	3 155	3 547	4 737	186 387	1 561	95 242
1971	214.6	173 094	24.1	3 518	3 463	2 516	187 306	2 122	96 073
1981	279.9	234 374	24.3	3 278	4 154	1 405	179 105	8 190	92 413
1982	237.4	219 418	21.3	2 639	3 900	1 304	155 897	2 108	98 927
1983	249.6	225 380	21.2	2 932	3 783	1 337	149 432	2 142	99 444
1984	283.4	253 971	21.9	2 915	3 699	1 326	142 407	2 268	97 387
1985	272.0	242 121	22.9	3 040	3 509	1 286	130 185	2 264	95 670
1986	272.3	244 784	23.0	2 831	3 897	1 295	129 509	2 328	93 544
1987	285.5	267 764	23.7	2 709	3 855	926	121 679	2 317	94 184
1988	293.8	271 045	26.7	2 989	3 836	1 233	134 156	2 243	91 334
1989	280.8	249 036	31.1	3 178	3 809	1 281	128 540	2 167	89 104
1990	268.7	248 371	29.1	2 004	3 719	1 088	123 137	2 064	86 880
1991	274.1	260 537	4.3[3]	1 426	3 492	633	120 710	2 087	85 563
1992	264.6	250 607	4.2	1 439	3 466	621	118 206	2 027	85 191
1993	264.3	256 338	4.1	1 413	3 300	570	117 533	2 021	84 648
1994	295.1	288 432	4.2	1 440	3 324	549	116 510	2 154	83 851
1995	297.4	280 466	4.1	1 473	3 332	517	110 784	2 145	80 326
1996	299.5	282 489	4.1	1 519	3 293	466	109 578	2 076	77 387

Notes:
1. Consumes 97% to 100% diesel fuel.
2. Data for rail lines operated between 1982 and 1996 include co-owned lines and those operated under leases, contracts and traffic rights. Figures for the period concluding in 1981 do not include lines operated under traffic rights. These figures thus do not permit comparison with subsequent years.
3. Intercity rail services responsible for the vast majority of passenger rail transportation, including the suburban train network, fell into a different Standard Industry Classification (SIC), starting in 1991.

Sources:
Statistics Canada, *Rail in Canada*, Catalogue No. 52-216-XPB, Ottawa.
Statistics Canada, *Railway Transport, Part 1, Comparative Summary Statistics*, Catalogue No. 51-207, Ottawa.
Statistics Canada, *Railway Transport, Part 3, Equipment, Track and Fuel Statistics*, Catalogue No. 51-209, Ottawa.

An analysis of tonne-kilometres, the production indicator for the transportation industry, shows maritime transport is overtaking rail transport and trucking (tables 4.8.1 to 4.8.3). The big difference in production between these modes is due to the fact that maritime transport is the only mode used to send goods overseas, yielding much higher average distances per shipment.

Commercial passenger transportation

Since 1990, air transport has experienced the sharpest growth of any form of commercial passenger transportation (Figure 4.8.3). In addition to dominating intercity transpor-

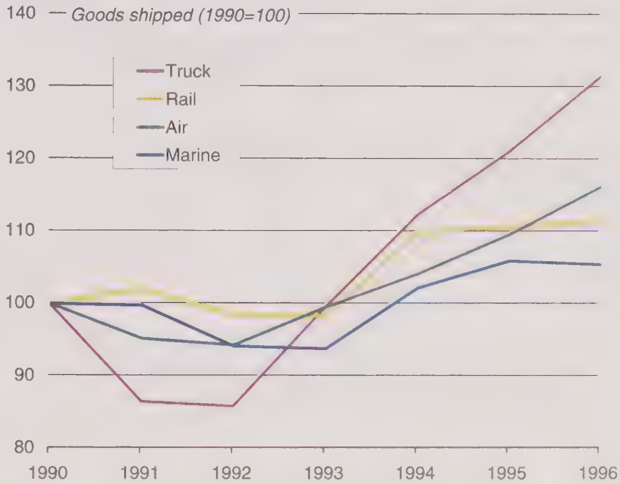
Table 4.8.3
Truck Transport, 1989-1997

Year	Freight carried		Shipments		
	tonnes	tonne-km	Number of shipments	Weight per shipment	Distance per shipment
	millions			kilograms	kilometres
1989	189.6	77 383	34.9	5 431	621
1990	174.2	77 069	30.0	5 816	647
1991	150.6	70 048	29.1	5 178	648
1992	149.5	72 276	27.6	5 410	656
1993	173.4	83 968	27.9	6 208	659
1994	195.6	101 873	30.5	6 418	641
1995	210.9	109 434	32.3	6 523	685
1996	229.0	120 459	35.2	6 509	709
1997	223.3	130 141	32.1	6 962	792

Note:
These figures pertain only to Canadian shippers. Other factors may be considered when interpreting such data, particularly changes made to the structure of the sampling base.

Source:
Statistics Canada, *Trucking in Canada*, Catalogue No. 53-222-XPB, Ottawa.

Figure 4.8.2
Goods Shipped by Mode of Transportation, 1990-1996



Sources:
Statistics Canada, *Canadian Civil Aviation*, Catalogue No. 51-206-XPB, Ottawa.
Statistics Canada, *Trucking in Canada,* Catalogue No. 53-222-XPB, Ottawa.
Statistics Canada, *Rail in Canada*, Catalogue No. 52-216-XPB, Ottawa.
Statistics Canada, *Shipping in Canada*, Catalogue No. 54-205-XPB, Ottawa.

Table 4.8.4
Air Transport, 1988-1997

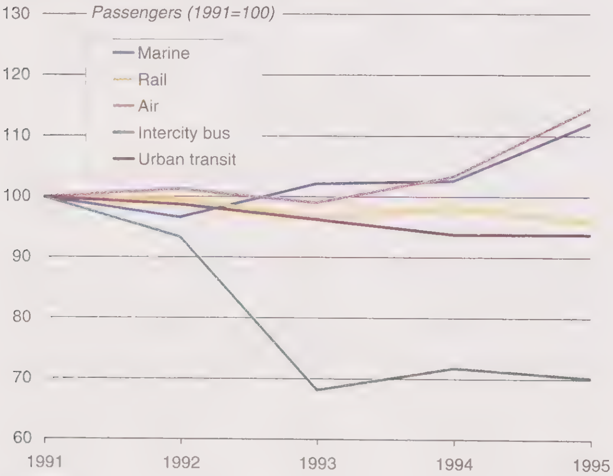
Year	Freight carried: weight	Freight carried: tonne-kilometres	Passengers: passengers	Passengers: passenger-kilometres
	tonnes		millions	
1988	592 700	1 516	34.8	62 140
1989	604 520	1 552	35.8	65 664
1990	631 932	1 743	36.3	66 606
1991	603 392	1 565	31.3	57 953
1992	597 201	1 492	31.9	62 108
1993	625 635	1 636	31.1	60 676
1994	653 421	1 791	32.5	65 634
1995	690 875	2 034	36.0	73 492
1996	725 863	2 167	39.5	82 120
1997	813 558	2 359	43.8	91 801

Note:
Figures include all Canadian airlines that transported more than 5 000 paying passengers or more than 1 000 tonnes of paid freight over each of the two calendar years preceding the year of the report. Figures exclude airlines holding permits for the sole purpose of serving the needs of a lodge operation.
Source:
Statistics Canada, *Canadian Civil Aviation*, Catalogue No. 51-206-XPB, Ottawa.

tation with 73.7% of the 1996 traffic (Figure 4.8.4), the number of passengers carried by this means of transportation rose 8.8% from 1990 (Table 4.8.4). This result fits into a trend in which the number of passengers has risen at an average annual rate of 2.9%, from 1988 to 1997. A restructuring of the air transport sector beginning in the early 1990s has served to increase seat occupancy rates, among other things.

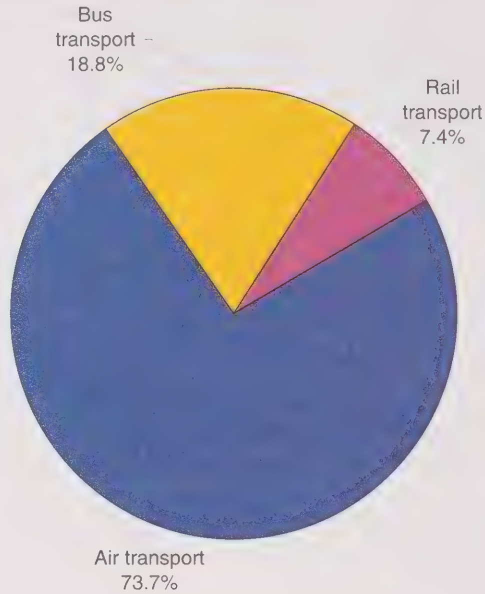
Long-distance passenger transportation by rail has been losing steam since the early 1990s. After having expanded during the 1980s, the number of passengers travelling in this manner dropped 4.7% between 1991 and 1996 (Table 4.8.2). The use of public and intercity bus transportation also declined over the same period (Table 4.8.5).

Figure 4.8.3
Passengers Transported by Mode of Transportation, 1991-1995



Sources:
Statistics Canada, *Canadian Civil Aviation*, Catalogue No. 51-206-XPB, Ottawa.
Statistics Canada, *Rail in Canada*, Catalogue No. 52-216-XPB, Ottawa.
Statistics Canada, *Shipping in Canada*, Catalogue No. 54-205-XPB, Ottawa.
Statistics Canada, *Passenger Bus and Urban Transit Statistics*, Catalogue No. 53-215-XPB, Ottawa.

Figure 4.8.4
Intercity Passengers by Mode of Transportation, 1996



Sources:
Statistics Canada, *Canadian Civil Aviation*, Catalogue No. 51-206-XPB, Ottawa.
Statistics Canada, *Rail in Canada*, Catalogue No. 52-216-XPB, Ottawa.
Statistics Canada, *Passenger Bus and Urban Transit Statistics*, Catalogue No. 53-215-XPB, Ottawa.

Finally, transportation of passengers by ferryboat, mostly concentrated on the West Coast, has been enjoying substantial growth. In 1995, 37 million passengers travelled by sea.

Private transportation

Private transportation primarily refers to transportation of individuals between their homes and either places of recreation or places of work. Most travel in the latter case is by private car.

In 1997, 17.5 million motor vehicles were registered in Canada (Table 4.8.6), an increase of nearly half a million over 1990. Private cars remained the most common vehicles, with 13.5 million travelling on Canadian highways in 1997. This number represented 77% of all registered highway vehicles. Trucks and truck tractors ranked second that year, with 20% of all registered vehicles. However, the number of motorcycles and mopeds represented only 1.8% of the number of highway vehicles registered in 1997, a decline from the 3.5% reported in 1984.

In 1996, 73% of those employed used their cars to get to work (Figure 4.8.5). Most travel between home and workplace represented a distance of less than 10 kilometres. However, this distance tended to rise along with the size of the population within the census metropolitan area (see section 7.5–**Public participation**).

Table 4.8.5
Transportation by Bus and Mass Transit, 1980-1997

Year	Distance travelled: Intercity transportation	Distance travelled: Mass transit	Distance travelled: Other[1]	Distance travelled: Total	Paying passengers: Intercity transportation	Paying passengers: Mass transit	Paying passengers: Total	Number of vehicles: Intercity transportation	Number of vehicles: Mass transit	Number of vehicles: Other[1]	Number of vehicles: Total
	thousand kilometres				thousands			number			
1980	203 119	656 245	421 033	1 280 397	33 282	1 307 199	1 340 481	1 805	12 670	21 761	36 236
1981	185 014	698 858	471 986	1 355 858	29 585	1 368 870	1 398 455	1 704	12 856	21 646	36 206
1982	197 838	712 436	478 011	1 388 285	31 187	1 333 121	1 364 308	1 683	13 318	22 773	37 774
1983	194 388	565 588	470 888	1 230 864	32 032	1 382 908	1 414 940	1 526	13 233	22 598	37 357
1984	182 773	691 373	483 437	1 357 583	27 834	1 413 676	1 441 510	1 558	13 212	21 679	36 449
1985	173 613	725 991	522 767	1 422 371	26 943	1 448 275	1 475 218	1 538	13 496	23 562	38 596
1986	174 717	757 748	504 128	1 436 593	22 871	1 522 160	1 545 031	1 417	13 032	24 210	38 659
1987	170 953	695 785	553 945	1 420 683	22 686	1 469 245	1 491 931	1 429	13 481	25 892	40 802
1988	157 052	749 934	541 509	1 448 495	18 262	1 514 979	1 533 241	1 308	13 379	24 345	39 032
1989	156 039	780 642	559 951	1 496 632	17 233	1 520 421	1 537 654	1 273	12 720	23 240	37 233
1990	168 159	769 326	537 705	1 475 190	16 991	1 528 400	1 545 091	1 356	13 156	22 516	37 028
1991	163 601	780 825	501 985	1 446 411	15 916	1 450 057	1 465 973	1 430	13 542	23 370	38 342
1992	148 526	754 399	604 215	1 507 140	14 872	1 432 105	1 446 977	1 388	12 956	27 688	42 032
1993	138 695	756 634	574 525	1 469 854	10 863	1 396 451	1 407 314	1 252	13 527	27 319	42 098
1994	165 843	776 471	638 885	1 581 199	11 438	1 360 708	1 372 146	1 388	13 411	27 006	41 805
1995	153 776	742 260	781 348	1 677 384	11 186	1 361 062	1 372 248	1 191	13 140	29 174	43 505
1996	130 359	716 369	756 959	1 603 687	10 270	1 352 870	1 363 140	1 052	13 049	31 438	45 449
1997	117 679	749 963	733 201	1 600 843	11 358	1 382 242	1 393 600	1 125	13 077	32 044	46 246

Notes:
Although we have no detailed data on this subject, intercity transportation by bus should, in principle, also be considered a means of shipping freight. In 1990, express package and delivery services represented 25% of the income for this sector.
In 1989, surveys on intercity bus transportation and mass transit were limited to transportation companies with incomes of at least $500 000.
In 1987 and 1988, only transportation companies with incomes of at least $250 000 were included. Prior to 1987, the threshold for inclusion was $100 000.
Before 1987, the inclusion threshold was $100 000.
1. Includes school transportation, charter bus services, shuttle services, tourist transportation and other transportation services.
Source:
Statistics Canada, *Passenger Bus and Urban Transit Statistics,* Catalogue No. 53-215-XPB, Ottawa.

Table 4.8.6
Motor Vehicle Registration, 1980-1997

Year	Highway vehicles: Private cars	Highway vehicles: Trucks and truck cabs	Highway vehicles: Buses	Highway vehicles: Motorcycles	Highway vehicles: Mopeds	Highway vehicles: Other vehicles[1]	Highway vehicles: Total	Non-highway vehicles: Snowmobiles	Non-highway vehicles: Other vehicles[2]
	thousands								
1980	10 256	2 903	52	389	68	50	13 717	476	197
1981	10 200	3 138	54	407	39	12	13 850	509	162
1982	10 530	3 239	54	431	42	13	14 309	451	191
1983	10 732	3 308	57	466	43	14	14 620	400	222
1984	10 781	3 047	52	470	37	19	14 406	425	208
1985	11 118	3 095	54	453	35	64	14 819	455	295
1986	11 586	3 156	57	430	35	72	15 337	488	365
1987	11 686	3 517	59	414	34	83	15 794	532	375
1988	12 086	3 706	60	370	31	84	16 336	546	407
1989	12 380	3 827	63	348	30	72	16 720	600	392
1990	12 622	3 867	64	331	28	69	16 981	636	429
1991	13 061	3 680	64	324	27	67	17 223	661	445
1992	13 322	3 624	64	313	27	61	17 411	689	474
1993	12 925	3 345	63	311	26	47	16 717	728	497
1994	13 131	3 393	64	306	24	53	16 971	745	513
1995	13 192	3 411	64	298	22	60	17 047	735	548
1996	13 251	3 476	65	291	21	79	17 183	709	560
1997^{p}	13 487	3 527	65	299	20	80	17 478	707	598

Notes:
1. Includes ambulances, fire trucks, hearses, etc.
2. Includes farm tractors and registered construction vehicles.
Source:
Statistics Canada, *Road Motor Vehicle Registrations*, Catalogue No. 53-219-XPB, Ottawa.

4.8.2 The impact of transportation on the environment

Transportation activities have an impact on the environment (Text Box 4.8.1). Infrastructural development represents a significant share of such consequences. The construction of transportation systems occupies vast amounts of land, intrudes into natural habitats and permanently alters the landscape. For example, the Canadian road network was equivalent to 901 904 kilometres of two-lane roads in 1995 (Table 4.8.7), a 7.5% rise over 1985. Two-thirds of these roads were gravel or dirt.

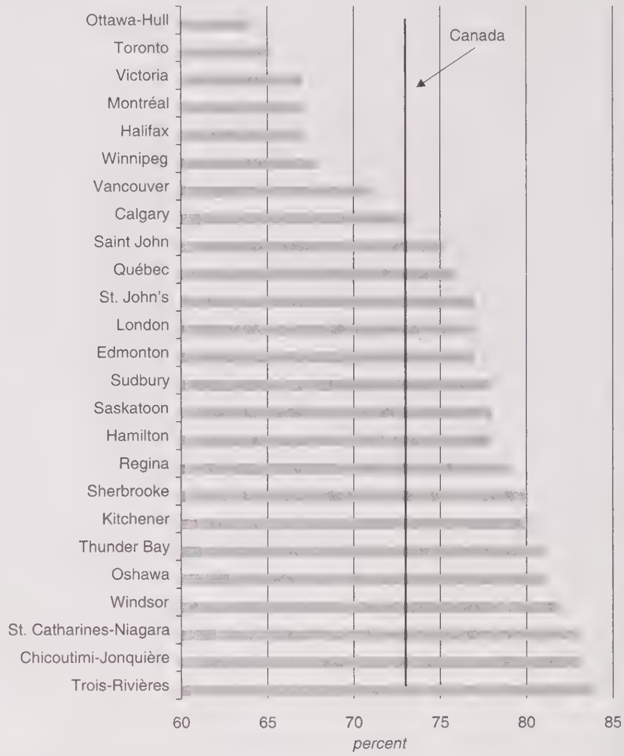
However, on both the regional and planetary scales, transportation's main impact on the environment is due to the fact that vehicles consume large quantities of fossil fuels. This consumption exhausts fuel resources and releases pollutants into the atmosphere.

Since 1991, there has been a consistent increase in the quantity of greenhouse gases emitted (Table 4.8.8). Vehicles consuming fossil fuels were partly responsible for this problem. In 1995, the transportation sector represented 26.8% of all greenhouse gases produced in Canada. During that year alone, atmospheric pollutants from transportation activities totalled 150 000 kilotonnes of carbon dioxide (CO_2), 20 kilotonnes of methane (CH_4) and 48 kilotonnes of nitrous oxide (N_2O) (Table 4.8.9). Since 1991, nitrous oxide and carbon dioxide emissions have been on the rise. Methane emissions, however, have been level since 1992.[1]

Emissions of gas into the atmosphere from transportation industry activities are directly proportional to the amounts of fossil fuels consumed. Fuel consumption varies according to the strength of the economy, but is particularly influenced by factors like the number of vehicles on Canadian roads, their energy efficiency and the distances they travel. Of all forms of transportation, those involved in the trucking industry consume the most. Commercial and public transportation have experienced the sharpest rises in fuel consumption—57% between 1991 and 1996 (Table 4.8.10). However, fuel consumption for private transportation (retail sales) was almost 500% greater. Total consumption of refined petroleum products by the transportation industry was 49.8 million m^3 in 1996, a 14.5% increase over that of 1991.

1. Other gases produced by the use of motor vehicles, such as carbon monoxide (CO), nitrogen oxides (NO_x) and volatile organic compounds, contribute indirectly to the greenhouse effect. For example, CO present in the atmosphere is subjected to integral oxidation and becomes CO_2 within 5 to 20 weeks of its discharge (Intergovernmental Group of Experts on the Evolution of the Climate, 1990, *Scientific Assessment of Climate Change*, United Kingdom).

Figure 4.8.5
Workforce Using Their Own Car to Get to Work by Census Metropolitan Area, 1996



Source:
Statistics Canada, 1998, *Nation Series, Edition 3*, Catalogue No. 93F0020, Ottawa.

Table 4.8.7
Road Network by Province and Territory, 1995

	Government			
Province/Territory	Federal	Provincial / territorial	Municipal	Total
	two-lane equivalent kilometres			
Newfoundland	207	8 747	4 127	13 081
Prince Edward Island	57	5 128	502	5 687
Nova Scotia	291	23 371	2 330	25 992
New Brunswick	219	18 480	3 185	21 884
Quebec	534	29 344	90 000	119 878
Ontario	2 346	28 458	137 087	167 891
Manitoba	1 740	21 628	64 500	87 868
Saskatchewan	3 181	26 200	172 522	201 903
Alberta	3 973	18 292	159 172	181 437
British Columbia	2 050	42 279	21 399	65 728
Yukon Territory	94	4 696	278	5 068
Northwest Territories	390	4 307	790	5 487
Total	**15 082**	**230 930**	**655 892**	**901 904**

Note:
Road categories cannot be perfectly compared between provinces and territories because road definitions vary considerably by government. The habit of referring to 'two-lane equivalent kilometres' is a product of such differences. We can estimate the real length of these highways by applying a factor of 1.02 km for every two-lane equivalent kilometre.
Source:
Transportation Association of Canada, 1995, *Transportation in Canada: A Statistical Overview*, Ottawa.

Text Box 4.8.1

Selected Environmental Impacts by Mode of Transport

Mode	Impacts: Air	Water resources	Land resources	Solid waste	Noise	Risk of accident	Other impacts
Road transport	local and regional air pollution: CO, HC, NO_x, particulates and fuel additives (e.g., lead) global pollution: CO_2, CFCs	pollution of surface water and groundwater through surface run-off modification of water systems by road building	land taken by infrastructure extraction of road-building materials	road vehicles and parts taken out of service waste oil	noise and vibration from vehicles, in cities and along main roads	deaths, injuries and property damage from road accidents release of material in transporting hazardous substances	partition or destruction of neighbourhoods, farmland and wildlife habitat congestion
Rail transport	local, regional and global air pollution	modification of water systems in railway construction	land taken for terminals, track and rights of way dereliction of obsolete facilities	abandoned lines, vehicle stock and related equipment	noise and vibration around terminals and along railway lines	release of material in transporting hazardous substances	partition or destruction of neighbourhoods, farmland and wildlife habitat
Air transport	local, regional and global air pollution	modification of water systems in airport construction	land taken for airport facilities dereliction of obsolete facilities	aircraft and parts taken out of service	noise and vibration around airports	deaths, injuries and property damage from aircraft accidents (but slight compared with road transport)	partition or destruction of neighbourhoods, farmland and wildlife habitat
Marine and inland water transport	local, regional and global air pollution	release of substances (e.g., discharge of ballast water, oil spills) modification of water systems in port construction, canal cutting and dredging	land taken for infrastructure dereliction of obsolete port facilities and canals	vessels and parts withdrawn from service	noise and vibration around terminals and port facilities	release of material in transporting hazardous substances (e.g., bulk transport of fuel)	partition or destruction of wildlife habitat

Source:
Modified from "Transport and the Environment: Facts and Figures," 1993, *Industry and Environment*, Vol. 16, (January-June), pp. 1-2.

Substitute energy sources like propane, natural gas and electricity increased their respective market shares over the past few years. Use of these energy sources rose 0.6% between 1990 and 1995, representing 2% of the energy used to transport passengers in 1995.[1]

1. Natural Resources Canada, 1997, *Energy Efficiency Trends in Canada, 1990 to 1995*, Ottawa.

Table 4.8.8
Greenhouse Gas (CO_2) Emissions from Mobile Sources, 1990-1995

Source	1990	1991	1992	1993	1994	1995
			kilotonnes			
Automobiles	56 100	55 100	56 100	59 600	61 600	62 000
Light trucks running on gasoline	23 000	23 000	24 800	24 600	26 100	26 900
Heavy trucks running on gasoline	2 370	2 250	2 280	2 170	2 140	2 050
Motorcycles	179	177	182	184	189	187
All-terrain vehicles running on gasoline	5 380	4 610	4 000	3 840	3 940	3 960
Light automobiles running on diesel	839	841	856	861	892	898
Light trucks running on diesel	952	904	928	941	1 020	1 090
Heavy trucks running on diesel	24 300	23 500	24 100	25 400	27 800	29 900
All-terrain vehicles running on diesel	11 500	10 300	9 610	10 800	12 400	13 900
Aircraft	10 600	9 570	9 720	9 030	10 100	10 800
Trains	6 610	6 130	6 410	6 380	6 610	5 980
Boats and vessels	5 990	6 440	6 390	5 550	5 850	5 600
Miscellaneous	1 680	1 870	1 890	2 090	2 290	2 360
Total for the transportation industry	**149 500**	**144 692**	**147 266**	**151 446**	**160 931**	**165 625**
Canada[1]	**567 000**	**559 000**	**575 000**	**581 000**	**599 000**	**619 000**
			percent			
Transportation industry as proportion of total	26.4	25.9	25.6	26.1	26.9	26.8

Notes:
Figures may not add up to totals due to rounding.
1. Does not include carbon dioxide from combustion of biomass.
Source:
Environment Canada, 1997, *Trends in Canada's Greenhouse Gas Emissions (1990-1995)*, Catalogue No. En49-5/5-8E, Ottawa.

Table 4.8.9
Emissions of Selected Greenhouse Gases by the Transportation Industry, 1990-1995

Year	CO_2	CH_4	N_2O
	kilotonnes		
1990	140 000	23	29
1991	134 000	21	31
1992	136 000	20	35
1993	139 000	20	40
1994	147 000	20	45
1995	150 000	20	48

Source :
Environment Canada, 1997, *Trends in Canada's Greenhouse Gas Emissions (1990-1995)*, Catalogue No. En49-5/5-8E, Ottawa.

Table 4.8.10
Consumption of Refined Petroleum Products by Mode of Transportation, 1991-1996

Year	Mode of transportation						
	Rail	Air	Sea	Commercial highway[1]	Private	Other	Total
	thousand m^3						
1991	2 143	2 658	2 835	4 405	31 447	15	43 503
1992	2 241	2 806	2 763	4 617	32 080	12	44 519
1993	2 232	2 786	2 448	5 066	33 000	8	45 540
1994	2 310	3 051	2 626	5 940	34 208	30	48 165
1995	2 092	3 224	2 554	6 454	34 251	36	48 611
1996	2 046	3 736	2 505	6 923	34 533	57	49 800

Notes:
'Refined petroleum products' refers to diesel oils, light heating oils, residual fuel oils, aviation gasoline, fuel for gas turbines and motor fuel.
1. Includes mass transit.
Source:
Statistics Canada, *Quarterly Report on Energy Supply-Demand in Canada*, Catalogue No. 57-003-XPB, Ottawa.

5 Natural Resources

Introduction

Canada's rich fur, fish and timber resources were fundamental to the nation's early economic development. Today, Canada maintains a global reputation as a reliable source of high-quality natural materials.

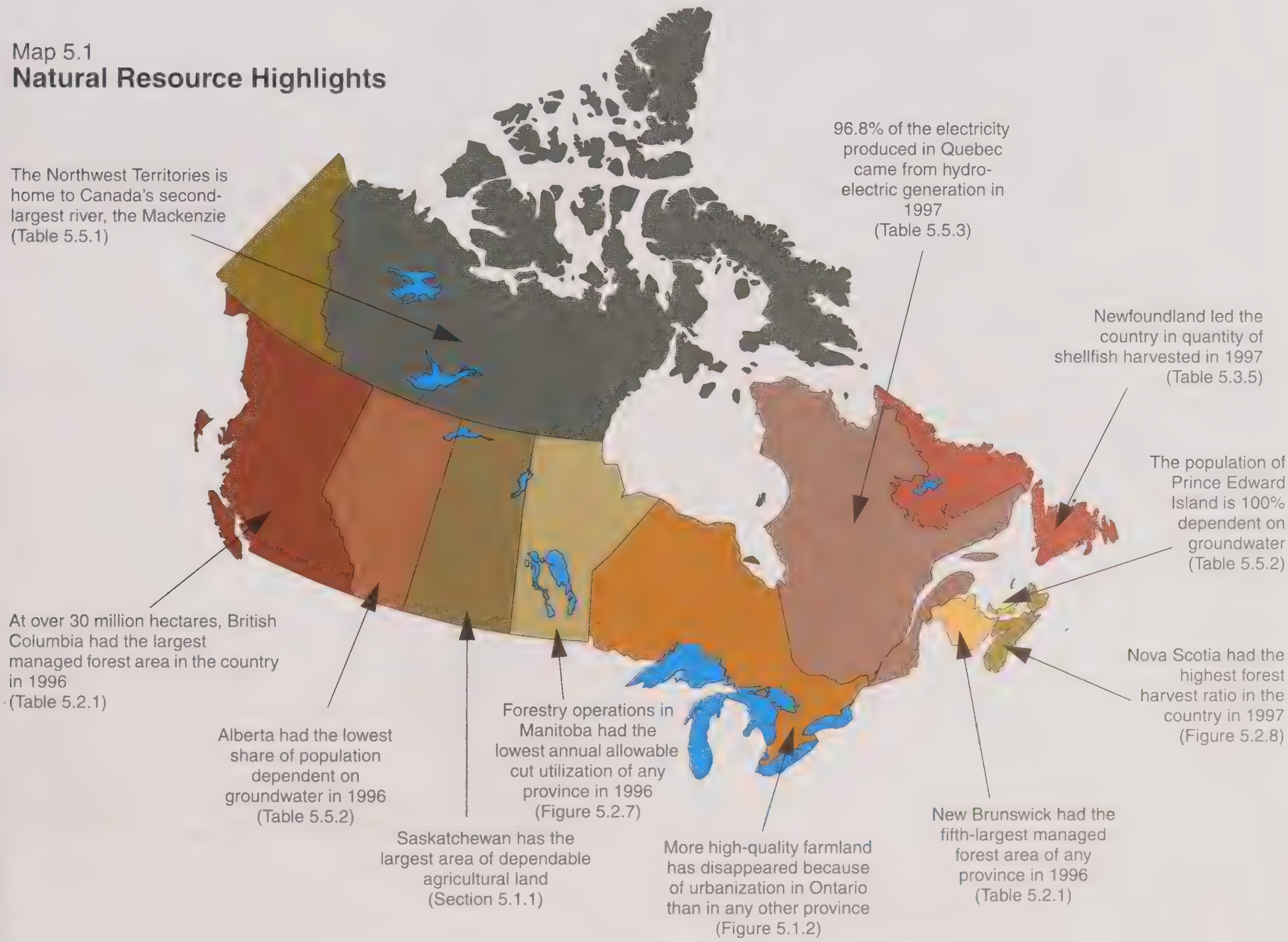
This chapter presents statistics covering Canada's agricultural, forest, marine, wildlife, water, energy and mineral resources. Each resource is examined with respect to stock size, annual production and consumption, and management efforts.

The statistics presented here provide readers with an understanding of the role that Canada's environment plays as a source of natural resources. Such information is one element in the assessment of the benefits that Canadians draw from their environment. Presenting statistics on stock size along with those on resource consumption and management also provides a starting point for answering questions about the sustainability of resource use.

The data show both promising and troubling trends. For example, section 5.1–**Agricultural resources** shows that our farmland is being used more intensively than ever, but that farmers are also paying greater attention to land management. Likewise, section 5.3–**Marine resources** indicates that while many of Canada's groundfish stocks remain severely depleted, aquaculture production of salmon and other high-value species is rising rapidly.

It is also clear that the data available to assess Canada's natural resources are of uneven quality. As shown in section 5.4–**Wildlife resources**, data on the size of our wildlife populations are particularly scarce. Data on water are also limited; for example, despite the fact that some 30% of the population was reliant on groundwater for household use in 1996, there are no good estimates of the extent of Canada's groundwater resources.

Map 5.1
Natural Resource Highlights



5.1 Agricultural resources

Today, 11% of the earth's land surface—more than 1.47 billion hectares of land[1]—is under crops. Globally, each hectare of cropland supports an average of more than 4.1 people.[2] This average, which was fewer than 3.5 people in the mid-1980s, increases as global population expands, currently at a rate of about 1.4% per year.

5.1.1 Agricultural land supply

The Canada Land Inventory (CLI) provides an estimate of the supply of agricultural land in Canada. CLI soil capability classes 1 to 3 represent Canada's dependable land for crop production (Map 5.1.1, Table 5.1.1 and Text Box 5.1.1). Soils in these classes have fair to high capability for crop production and are considered suitable for long-term use. Some soils in CLI classes 4 and 5 are used for crop production today, although they are subject to severe limitations.

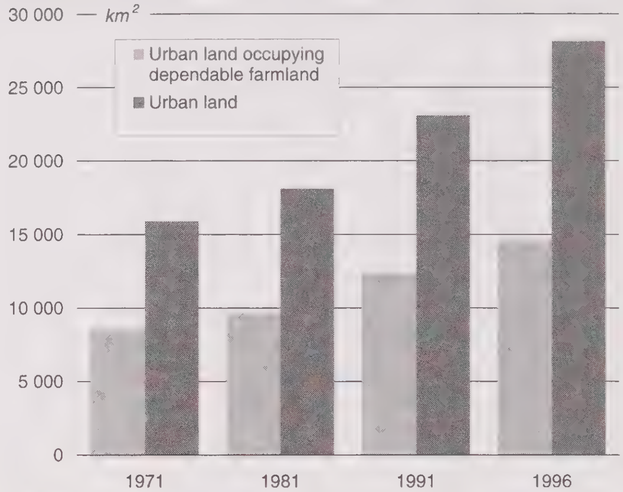
As shown in Table 5.1.1, Canada has 454 630 km^2 of dependable land. This represents about 5% of our total land area. Saskatchewan and Alberta are home to the largest areas of dependable land, with 162 988 km^2 and 107 289 km^2, respectively; Ontario follows with 72 833 km^2.

Prime agricultural land—CLI class 1—is in very limited supply in Canada. It occupies less than one-half of one percent of Canada's land area. The bulk of this land (52%) is located in southern Ontario, which has 21 568 km^2 of CLI class 1 land. It is estimated that 37% of this land can be seen from the top of Toronto's CN tower on a clear day.[3] Other provinces with significant prime land areas include Saskatchewan (9 997 km^2) and Alberta (7 865 km^2).

Virtually all of Canada's dependable agricultural land is currently used for agriculture, unless it is paved over or built on. And, as can be seen in Figure 5.1.1, the amount of dependable agricultural land paved over or built on increased substantially between 1971 and 1996. As Canadian cities and towns expanded during this period, some 12 250 km^2 of land were given over to urban uses. Of this area, almost half (5 900 km^2) was dependable agricultural land.

1. This is an area roughly 1.5 times the size of Canada.
2. World Resources Institute, 1998, *World Resources 1998–99*, Oxford University Press, London.
3. Environment Canada,1979, *Canada's Special Resource Lands*, Ottawa.

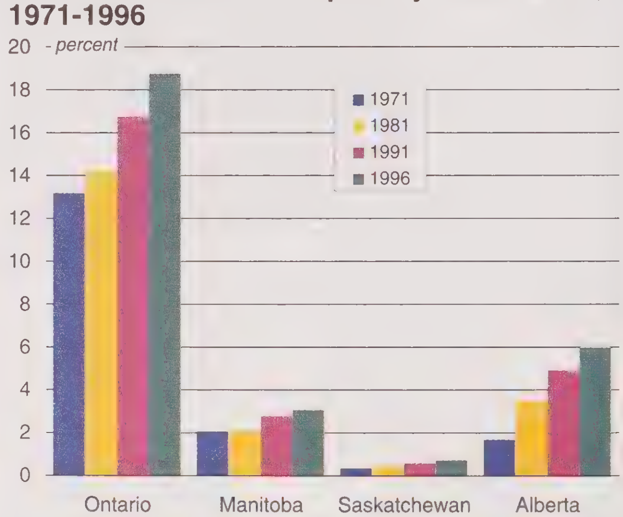
Figure 5.1.1
Urban Land Use, 1971-1996



Sources:
Statistics Canada, Census of Population, and Environment Accounts and Statistics Division.

By 1996, approximately 19% of Ontario's prime agricultural land (CLI class 1) had been displaced by urban uses (Figure 5.1.2). By the same year, Alberta had lost 6% of its prime land. Saskatchewan, the other province with a significant amount of prime land, had lost less than 1%.

Figure 5.1.2
Class 1 Farmland Occupied by Urban Land, 1971-1996



Sources:
Statistics Canada, Census of Population, and Environment Accounts and Statistics Division.

Map 5.1.1
Dependable Agricultural Land

Sources:
Environment Canada, 1982, Lands Directorate, CGIS Database.
Statistics Canada, 1999, Environment Accounts and Statistics Division, Environmental Information System (EIS) Database

Table 5.1.1
Canada Land Inventory: Soil Capability for Agriculture

Province/Territory	Agricultural soil capability class 1	2	3	4	5	6	7	Organic[1]	Unclassed[2]	Not classified	Total area
	km²										
Newfoundland	-	-	19	166	915	2 074	6 441	2 179	14 469	379 457	405 720
Prince Edward Island	-	2 616	1 415	498	761	-	277	67	2	25	5 660
Nova Scotia	-	1 663	9 829	4 244	822	133	35 160	1 163	9	2 467	55 490
New Brunswick	-	1 605	11 511	20 321	17 003	115	18 386	1 328	1 153	2 018	73 440
Quebec	196	9 071	12 772	25 805	16 586	107	205 996	15 169	1 321	1 253 658	1 540 680
Ontario	21 568	22 177	29 088	26 246	19 153	11 403	112 213	25 633	7 827	793 272	1 068 580
Manitoba	1 625	25 306	24 407	23 941	23 238	20 922	10 886	47 417	38 582	433 626	649 950
Saskatchewan	9 997	58 744	94 247	38 931	87 363	39 501	2 255	27 886	11 270	282 135	652 330
Alberta	7 865	38 371	61 053	92 796	110 931	39 307	41 914	59 920	26 589	182 445	661 190
British Columbia	211	2 355	6 920	17 017	66 717	54 191	152 548	-	-	647 842	947 800
Yukon Territory[3]	..	..	..	..	..	..	..	..	..	483 450	483 450
Northwest Territories[3]	..	..	..	..	..	..	..	..	..	3 426 320	3 426 320
Canada	**41 461**	**161 908**	**251 261**	**249 965**	**343 488**	**167 752**	**586 077**	**180 762**	**101 222**	**7 886 715**	**9 970 610**
	percent share by class										
Newfoundland	-	-	0.01	0.07	0.27	1.24	1.10	1.21	14.29	4.81	4.07
Prince Edward Island	-	1.62	0.56	0.20	0.22	-	0.05	0.04	--	--	0.06
Nova Scotia	-	1.03	3.91	1.70	0.24	0.08	6.00	0.64	0.01	0.03	0.56
New Brunswick	-	0.99	4.58	8.13	4.95	0.07	3.14	0.73	1.14	0.03	0.74
Quebec	0.47	5.60	5.08	10.32	4.83	0.06	35.15	8.39	1.31	15.90	15.45
Ontario	52.02	13.70	11.58	10.50	5.58	6.80	19.15	14.18	7.73	10.06	10.72
Manitoba	3.92	15.63	9.71	9.58	6.77	12.47	1.86	26.23	38.12	5.50	6.52
Saskatchewan	24.11	36.28	37.51	15.57	25.43	23.55	0.38	15.43	11.13	3.58	6.54
Alberta	18.97	23.70	24.30	37.12	32.30	23.43	7.15	33.15	26.27	2.31	6.63
British Columbia	0.51	1.45	2.75	6.81	19.42	32.30	26.03	-	-	8.21	9.51
Yukon Territory[3]	..	..	..	..	..	..	..	..	..	6.13	4.85
Northwest Territories[3]	..	..	..	..	..	..	..	..	..	43.44	34.36
Canada	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**

Notes:
Figures may not add up to totals due to rounding.
Dependable land is the sum of Canada Land Inventory classes 1, 2 and 3.
1. Peatlands, bogs and marshes capable of supporting agricultural production and distinguishable from mineral soils by their high organic content.
2. Unmapped areas, water, forest reserves, national parks, urban areas and provincial parks.
3. Not covered by the Canada Land Inventory.

Sources:
Environment Canada, 1992, *Agricultural Land Use Change in Canada*, Ottawa.
Statistics Canada, Environmental Accounts and Statistics Division.

Text Box 5.1.1
Canada Land Inventory Classes 1, 2 and 3—Canada's Dependable Agricultural Land Base

Class 1 – Soils in this class have no significant limitations for crops. These deep soils are level or have very gentle slopes, are well to imperfectly drained and have a good water-holding capacity. They are easily maintained in good tilth and productivity, and the potential for damage from erosion is slight. They are moderately high to high in productivity for a wide range of field crops adapted to the region.

Class 2 – Soils in this class have moderate limitations that restrict the range of crops or require moderate conservation practices. These deep soils have a good water-holding capacity, can be managed with little difficulty and are moderately high to high in productivity for a fairly wide range of field crops. The moderate limitations on these soils may be from any one of a number of factors, including mildly adverse regional climate; moderate effects of erosion, poor soil structure or low permeability; low fertility correctable with lime; gentle to moderate slopes; and occasional overflow or wetness.

Class 3 – Soils in this class have moderate to severe limitations that restrict the range of crops or require special conservation practices. Under good management, these soils are fair to moderately fair in productivity for a wide range of field crops adapted to the region. Conservation practices are more difficult to apply and maintain. Limitations arise from a combination of two of the factors described under Class 2, or from one of the following factors: climate, erosion potential, low fertility, strong slopes, poor drainage, low water-holding capacity and salinity.

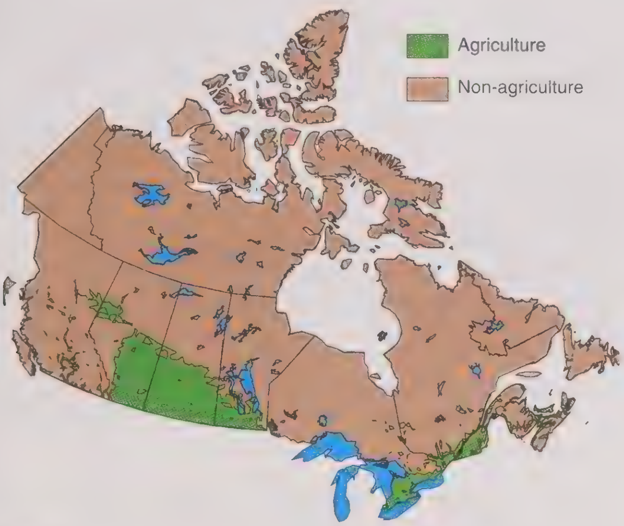
Note:
For more detail on the Canada Land Inventory and for a complete description of all land classes, please visit the Natural Resources Canada Web site at <http://www.cgdi.gc.ca>.

5.1.2 Agricultural land use

In 1996, Canada had 681 000 km^2—about 7.4% of its land—in agriculture. Map 5.1.2 shows the distribution of this land. Table 5.1.2 shows that the total area of Canadian agricultural land peaked in the 1940s and 1950s and has remained stable since the1960s.

In contrast, the number of farms has been declining steadily since the 1940s. In 1996, 276 548 farms were in operation, compared with 732 832 in 1941. With the decline in the number of farms has come an increase in average farm size, from 96 hectares in 1941 to 246 hectares in 1996.

Map 5.1.2
Agricultural Land



Source:
Statistics Canada, Agriculture Division.

Text Box 5.1.2
Census of Agriculture Land Definitions

Agricultural land – Total area of land operated on farms.

Cropland – Sum of all areas reported for field crops, tree fruits, berries, grapes, vegetables, nursery products, sod and Christmas trees.

Summerfallow – Land from which no crop is harvested, but that is worked or sprayed during the crop season, primarily for moisture conservation.

Improved pasture – Grazing land that has been improved by seeding, draining, irrigating or fertilizing, or had brush or weed control applied to it.

Cultivated land – The sum of cropland, improved pasture and summerfallow.

Improved land – The sum of cropland, improved pasture and summerfallow, as well as a portion of other land (for census years after 1986).

Unimproved land – Native pasture, rangeland, woodland, bogs and marshes.

Source:
Statistics Canada, Agriculture Division.

Table 5.1.2
Farms and Agricultural Land, 1901-1996

	Improved farmland							
Year	Cropland	Improved pasture	Summer-fallow	Other land[1,2]	Unimproved agricultural land[2]	Total agricultural land	Number of farms	Average farm size
	thousand km^2						number	hectares per farm
1901	81	--	--	41	135	257	511 073	50.3
1911	144	--	10	43	244	441	682 329	64.6
1921	202	31	48	5	284	570	711 090	80.2
1931	236	32	68	11	313	660	728 623	90.6
1941	228	34	95	14	331	702	732 832	95.8
1951	252	40	89	11	312	704	623 087	113.0
1961	253	41	114	10	280	698	480 877	145.1
1971	278	41	108	10	250	687	366 110	187.7
1976	283	41	109	9	242	684	338 552	202.0
1981	309	41	97	14	198	659	318 361	207.0
1986	332	36	85	7	218	678	293 089	231.3
1991	335	41	79	..	..	678	280 043	242.1
1996	349	43	63	..	..	681	276 548	246.1

Notes:
1. Refers to barnyards, laneways and other unclassified lands.
2. Other land and unimproved agricultural land can no longer be compiled because of census questionnaire changes.

Sources:
Statistics Canada, Agriculture Division.
Statistics Canada, 1998, *Handbook of Agricultural Statistics*, Catalogue No. 21-503, Ottawa.

Table 5.1.3
Agricultural Land Area and Average Farm Size by Ecozone, 1971 and 1996

Ecozone[1]	Ecozone area	Agricultural land 1971	Agricultural land 1996	Agricultural land Change 1971-1996	Proportion of ecozone in agricultural land 1971	Proportion of ecozone in agricultural land 1996	Average farm size 1971	Average farm size 1996	Average farm size Change 1971-1996
	km2				percent		hectares per farm		percent
Boreal Shield	1 876 142	20 160	15 526	-23.0	1.07	0.83	101.6	128.6	26.5
Atlantic Maritime	202 619	29 240	22 033	-24.6	14.43	10.87	85.6	106.3	24.2
Mixed Wood Plains	113 971	74 616	65 883	-11.7	65.47	57.81	62.1	80.2	29.0
Boreal Plains	704 719	123 960	136 289	9.9	17.59	19.34	240.1	311.5	29.7
Prairie	464 070	419 921	420 582	0.2	90.49	90.63	340.0	432.0	27.0
Montane Cordillera	490 234	17 064	18 547	8.7	3.48	3.78	203.5	188.9	-7.1
Pacific Maritime	213 000	1 664	1 687	1.4	0.78	0.79	19.5	15.9	-18.8
Canada	**4 064 755**	**686 624**	**680 550**	**-0.9**	**16.89**	**16.74**	**187.5**	**246.1**	**31.2**

Notes:
Figures may not add up to totals due to rounding.
1. Includes only ecozones where agriculture is practised.
Source:
Statistics Canada, Environment Accounts and Statistics Division.

Agriculture is dependent on ecological conditions. Most of Canada's ecozones have little or no agricultural land, while one consists almost entirely of agricultural land (see section 3.1–**Environmental geographies** for more detail on Canada's ecozones). For example, Table 5.1.3 shows that 90.6% of the Prairie ecozone was devoted to agriculture in 1996; this explains why very little of this ecozone remains in its natural state. The Mixed Wood Plains ecozone in eastern Canada had the next highest proportion of agricultural land, with more than 57.8% of its area in agriculture.

For the most part, the acreage of agricultural land expanded in western ecozones between 1971 and 1996, while it declined in eastern ecozones. The Boreal Plains ecozone experienced the greatest increase in agricultural land area (9.9%). The largest decline (-24.6%) occurred in the Atlantic Maritime ecozone.

In both 1971 and 1996, farm sizes varied significantly across ecozones. The eastern ecozones and those in British Columbia tended to have relatively small farms, while the Prairie ecozone tended to have much larger farms.

Looking more closely at the cultivated portion of agricultural land, Table 5.1.4 shows some significant changes between 1971 and 1996. In particular, cropland area increased by 25.5% during this period. At the same time, total agricultural land actually declined by nearly 1% (Table 5.1.3). Most of the increase in cropland occurred in the west, where large areas of summerfallow land were converted to full-time crop production. The largest decline in summerfallow area was in the Prairie ecozone, where more than 34 000 km^2 of summerfallow land were put to other uses. Some western ecozones also saw significant new ground broken for crop production between 1971 and 1996.

The decline in the practice of summerfallowing means that more land was cropped on a full-time basis than was the case 25 years earlier. The practice of summerfallowing has declined largely in response to evidence that it contributes to soil salinization.

Table 5.1.4
Cultivated Agricultural Land by Ecozone, 1971 and 1996

Ecozone[2]	Cropland 1971	Cropland 1996	Cropland Change 1971-1996	Summerfallow 1971	Summerfallow 1996	Summerfallow Change 1971-1996	Improved pasture 1971	Improved pasture 1996	Improved pasture Change 1971-1996	Total cultivated land[1] 1971	Total cultivated land[1] 1996	Total cultivated land[1] Change 1971-1996
	km2		percent	km2		percent	km2		percent	km2		percent
Boreal Shield	5 741	5 779	0.7	271	129	-52.2	2 740	1 070	-60.9	8 752	6 979	-20.3
Atlantic Maritime	8 459	7 996	-5.5	191	32	-83.4	3 481	1 312	-62.3	12 132	9 340	-23.0
Mixed Wood Plains	39 520	44 098	11.6	1 069	232	-78.3	11 672	3 716	-68.2	52 261	48 046	-8.1
Boreal Plains	49 007	66 202	35.1	17 222	6 904	-59.9	6 715	13 440	100.2	72 944	86 546	18.6
Prairie	173 005	221 725	28.2	89 353	55 199	-38.2	15 179	22 427	47.8	277 537	299 351	7.9
Montane Cordillera	1 981	1 002	-49.4	45	31	-32.7	549	219	-60.1	2 575	1 252	-51.4
Pacific Maritime	570	2 385	318.3	65	81	24.5	1 045	1 307	25.0	1 680	3 773	124.5
Canada	**278 285**	**349 187**	**25.5**	**108 216**	**62 607**	**-42.1**	**41 381**	**43 491**	**5.1**	**427 882**	**455 286**	**6.4**

Notes:
Figures may not add up to totals due to rounding.
1. The sum of cropland, summerfallow and improved pasture.
2. Includes only ecozones where agriculture is practised.
Source:
Statistics Canada, Environment Accounts and Statistics Division.

5.1.3 Management practices

Land management practices have considerable impact on the quality of agricultural land. Proper land management can increase soil fertility, serving to preserve and enhance land stocks. On the other hand, poor management can lead to soil degradation and a diminishing stock of usable land. A number of management practices that conserve soils are currently in use by farmers (Text Box 5.1.3).

Table 5.1.5 presents information on tillage practices compiled from the Census of Agriculture. Information on three tillage types was collected for the 1991 and 1996 census years. The area tilled conventionally declined by 23.3% during the period. Conventional tillage has the greatest potential negative impact on soil of the three tillage types listed in the table. The largest declines occurred in the Montane Cordillera and the Boreal Plains ecozones, where conventionally tilled areas declined by 43.7% and 28.4%, respectively. Table 5.1.5 also indicates that the more environmentally benign tillage types—conservation and no tillage—gained a larger share of the area prepared for seeding, increasing nationally by 23.6% and 135.3%, respectively. The largest proportionate increase in conservation tillage area occurred in the Atlantic Maritime ecozone, where the area tilled by this method increased by 63.1%. The Prairie ecozone had the largest absolute area increase for conservation tillage, with an increase of more than 10 000 km^2 over 1991 levels. The practice of no tillage jumped by the greatest share (324.1%) in the Mixed Wood Plains, while the Prairie ecozone again had the largest absolute increase in area (20 000 km^2).

Text Box 5.1.3
Methods of Soil Conservation

Several agricultural techniques that maintain and improve soil have been developed. No-till agriculture, for example, involves planting crops directly into the residue of the previous year's crop. This practice disturbs the soil's surface only minimally, conserving moisture, soil structure and organic matter and minimizing the risk of erosion. Conservation tillage is a similar practice that retains most of the residue from the previous crop at the soil surface. Both of these methods differ from conventional tillage, which incorporates most of the previous crop's residue into the ground, leaves the surface exposed to erosion and accelerates the decomposition of organic matter.

Green manures are crops that are grown specifically to be ploughed into the soil, adding both organic matter and nutrients in the process. They also prevent erosion by covering soil that would otherwise be left bare. Legumes (e.g., clover and vetch) are often used for this purpose because, unlike most other crops, they can collect nitrogen from the air. Their growth thus represents a net gain of nitrogen since they do not extract all of their nitrogen requirements from the soil.

Crop rotations can be used to prevent the build-up of pest populations and avoid depleting the same soil nutrients year after year. They also serve to improve soil structure when deep-rooting or high-residue crops are used in the rotation.

There are many other methods of improving soil and preventing erosion. A more detailed account can be found in *The Health of Our Soils: Toward Sustainable Agriculture in Canada.*[1]

1. Acton, D.F. and L.J. Gregorich (eds.), 1995, *The Health of Our Soils: Toward Sustainable Agriculture in Canada*, Centre for Land and Biological Resources Research, Agriculture and Agri-Food Canada, Catalogue No. A53-1906/1995E, Ottawa.

Table 5.1.5
Tillage Practices by Ecozone, 1991 and 1996

Ecozone[1]	Land prepared for seeding 1991	Land prepared for seeding 1996	Land prepared for seeding Change 1991-1996	Conventional tillage 1991	Conventional tillage 1996	Conventional tillage Change 1991-1996	Conservation tillage 1991	Conservation tillage 1996	Conservation tillage Change 1991-1996	No tillage 1991	No tillage 1996	No tillage Change 1991-1996
	km^2		percent	km^2		percent	km^2		percent	km^2		percent
Boreal Shield	2 080	1 772	-14.8	1 694	1 407	-16.9	298	265	-11.1	88	100	13.5
Atlantic Maritime	3 092	2 871	-7.2	2 731	2 294	-16.0	289	471	63.1	73	106	44.8
Mixed Wood Plains	31 064	31 122	0.2	24 731	19 801	-19.9	5 209	6 557	25.9	1 123	4 764	324.1
Boreal Plains	51 725	47 203	-8.7	41 208	29 508	-28.4	9 488	13 892	46.4	1 028	3 803	269.9
Prairie	201 285	203 249	1.0	128 657	99 810	-22.4	55 488	66 355	19.6	17 140	37 084	116.4
Montane Cordillera	737	492	-33.3	586	330	-43.7	121	108	-10.5	31	54	77.3
Pacific Maritime	304	221	-27.5	259	194	-25.2	18	20	13.5	28	7	-76.2
Canada	**290 288**	**286 928**	**-1.2**	**199 866**	**153 343**	**-23.3**	**70 910**	**87 668**	**23.6**	**19 512**	**45 918**	**135.3**

Note:
1. Includes only ecozones where agriculture is practised.

Sources:
Statistics Canada, Agriculture Division, and Environment Accounts and Statistics Division.

5.1.4 Agricultural crop and livestock production

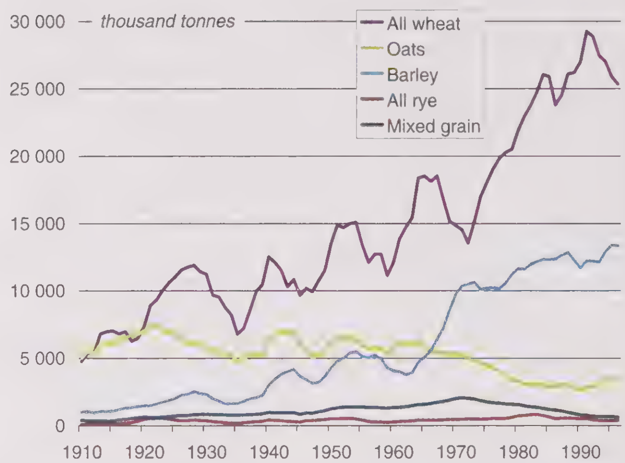
Crop production has more than quadrupled since 1910 (figures 5.1.3 and 5.1.4).[1] Many factors have contributed to this rise—new technologies involving mechanization, genetics, nutrient science and irrigation enable the farmer to be more productive than ever before.

Increased output has not come without costs to the environment. Pollution problems such as eutrophication of water bodies and soil erosion are linked to modern agricultural practices (see section 6.3–**Water quality** for more detail).

Figure 5.1.5[2] shows a large increase in cattle and pig stocks and a significant decline in sheep and horse stocks from earlier in the century. The number of cattle has more than doubled and the number of pigs has tripled since 1908.

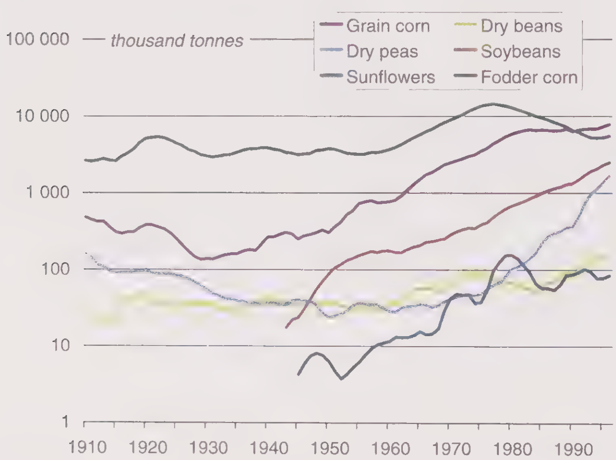
Livestock can also have significant environmental impacts. Based on ratios developed in the United States,[3] Canadian livestock generate the waste equivalent of an estimated 220 million people, almost seven times the population of Canada.

Figure 5.1.4
Production of Major Small Grains in Canada, 1910-1996 (Five-year Averages)



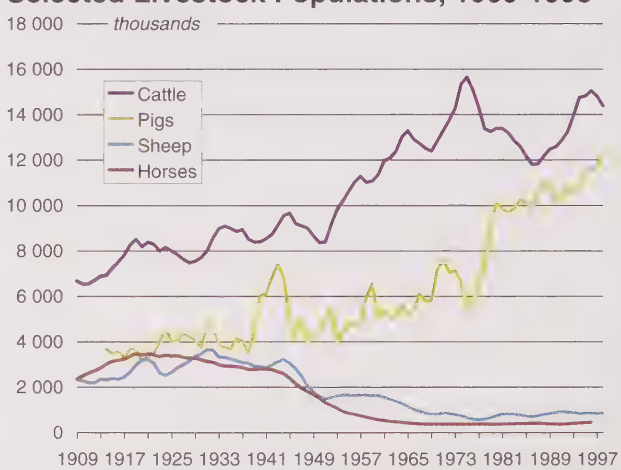
Source:
Statistics Canada, Agriculture Division.

Figure 5.1.3
Selected Field Crop Production, 1910-1996 (Five-year Averages)



Source:
Statistics Canada, Agriculture Division.

Figure 5.1.5
Selected Livestock Populations, 1909-1998



Source:
Statistics Canada, Agriculture Division.

1. Only major crops are included in figures 5.1.3 and 5.1.4.
2. Only selected livestock groups are included in Figure 5.1.5.
3. National Research Council, 1979, *Ammonia*, Washington, D.C.

5.2 Forest resources

After Russia, Canada has the largest continuous forested area in the world. Out of a total land area of 921.5 million hectares, 417.6 million hectares are defined in *Canada's Forest Inventory*[1] as forest land (Text Box 5.2.1). Much of this forest remains in a natural state.

Of the 417.6 million hectares of inventoried forest land, some 244.6 million are classified in *Canada's Forest Inventory* as timber-productive: forest land that is capable of producing a merchantable stand within a reasonable length of time. A further 169.7 million hectares are classified as timber-unproductive. The remaining 3.3 million hectares of Canada's inventoried forest land are classified as having unspecified productivity.

Canada's timber-productive forest land constitutes 7.1% of the world's productive forests.[2]

Text Box 5.2.1
Canada's Forest Inventory

Canada's Forest Inventory (CanFI94) is a compilation of provincial and territorial forest inventories. It contains the best available information on the distribution and structure of the nation's forests in 1994.

CanFI94 reports forest land area according to three forest types: softwood, mixedwood and hardwood. A **softwood** forest is one where the canopy or the cover type is over 75% coniferous species; a **mixedwood** forest is one where the canopy is between 25% and 75% coniferous species; and a **hardwood** forest has a canopy of less than 25% coniferous species.

The principal coniferous species are spruce, pine, fir, hemlock, Douglas-fir, larch and cedar. The principal non-coniferous, or broadleaved, species are poplar, birch and maple.

5.2.1 The managed forest

Of the 244.6 million hectares of timber-productive forest land in Canada, 235.6 million are available for harvesting; the remainder are reserved for non-timber purposes. Only 147.6 million hectares of the available forest land can be accessed for logging, however, and, of those, only 132.9 million hectares are adequately stocked with trees.

These 132.9 million hectares of timber-productive forest land constitute the area that is currently managed for timber production. On average, timber from approximately one million hectares of the managed forest is harvested on an annual basis.

The managed forest by province

Figure 5.2.1 and Table 5.2.1 show the area of managed forest by province and forest type. The provinces with the largest areas of managed forest—Quebec, Ontario, Alberta and British Columbia—are also the major producers of forest products in Canada.

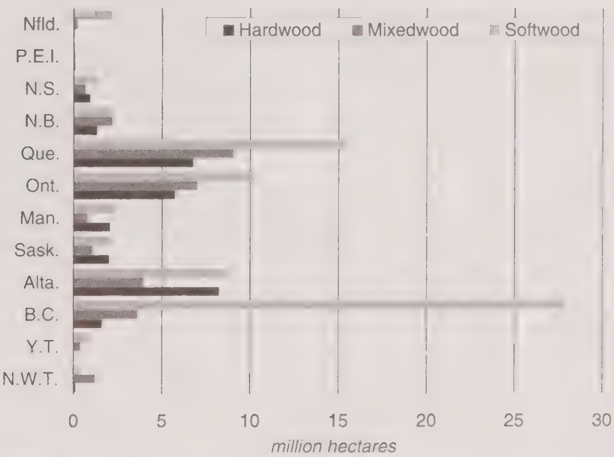
British Columbia leads in managed forest area with more than 30 million hectares of forest. The majority of British Columbia's forests are found in two ecozones: the coastal Pacific Maritime ecozone and the interior Montane Cordillera ecozone.

The Pacific Maritime ecozone is wet, mountainous and highly timber-productive. The principal commercial species found in this region are all coniferous: hemlock, western red cedar, Douglas-fir, balsam fir, yellow cedar and Sitka spruce. This region accounts for about 30% of the British Columbia harvest.

The Montane Cordillera ecozone is colder and drier. As a result it is less timber-productive. Here the principal commercial species are lodgepole pine, spruce, balsam fir, Douglas-fir, hemlock, larch, western red cedar and ponderosa pine. As on the coast, these are all coniferous species.

Quebec, Ontario and Alberta follow British Columbia in terms of managed forest area. Forests in the northern portions of these provinces, along with those in northern Saskatchewan and Manitoba, are located in the largest forested region of Canada—the Boreal Shield ecozone. This region is characterized mainly by softwood stands.

Figure 5.2.1
Managed Forest Area by Province and Territory, 1994



Source:
Lowe, J. J., K. Power and S.L. Gray, 1994, *Canada's Forest Inventory (1994 Version)*, Natural Resources Canada, Canadian Forest Service, Victoria.

1. Lowe, J.J., K. Power and S.L. Gray, 1994, *Canada's Forest Inventory (1994 Version)*, Natural Resources Canada, Canadian Forest Service, Victoria.
2. United Nations Food and Agriculture Organization, 1997, *State of the World's Forests 1997*, Rome.

Table 5.2.1
Area of Managed Forest by Province and Territory, 1997

Province/Territory	Managed forest area				Area harvested	Harvest ratio
	Softwood	Mixedwood	Hardwood	Total		
	hectares					percent
Newfoundland	2 146 705	234 284	52 632	2 433 621	19 800	0.81
Prince Edward Island	89 900	85 386	69 703	244 989	2 713	1.11
Nova Scotia	1 332 738	688 177	932 782	2 953 697	68 718	2.33
New Brunswick	2 250 221	2 189 289	1 337 980	5 777 490	84 115	1.46
Quebec	15 354 112	9 049 068	6 770 917	31 174 097	285 437	0.92
Ontario	10 158 483	7 016 216	5 721 265	22 895 964	184 921	0.81
Manitoba	2 411 345	796 175	2 066 056	5 273 576	15 544	0.29
Saskatchewan	2 083 282	1 089 229	2 031 465	5 203 976	17 500	0.34
Alberta	8 646 587	3 963 824	8 266 265	20 876 676	50 697	0.24
British Columbia	27 803 669	3 635 989	1 616 111	33 055 769	165 190	0.50
Yukon Territory	903 841	407 858	39 721	1 351 420	1 921	0.14
Northwest Territories	337 500	1 236 800	137 000	1 711 300	366	0.02

Sources:
Canadian Council of Forest Ministers, *Compendium of Canadian Forestry Statistics 1998: National Forestry Database Program*, Natural Resources Canada, Canadian Forest Service, <http://nfdp.ccfm.org>, (accessed December 5, 1999).
Lowe, J.J., K. Power and S.L. Gray, 1994, *Canada's Forest Inventory (1994 Version)*, Natural Resources Canada, Canadian Forest Service, Victoria.

As one moves south through Ontario and Quebec into the Mixed Wood Plains ecozone, the gradual addition of broad-leaved species yields mixedwood stands. These eventually give way to hardwood stands in the extreme south of the provinces.

The managed forests of Alberta, southern Saskatchewan and southern Manitoba are predominantly hardwood stands found in the Boreal Plains ecozone.

Map 5.2.1 shows the distribution of softwood, mixedwood and hardwood forests across Canada's inventoried forest land.

Timber volume

Timber volume is measured in terms of gross merchantable volume per hectare and expressed as m^3 per hectare. Gross merchantable volume is defined as the volume of a tree's main stem (trunk) excluding the stump and top but including defective and decayed wood.[1]

Map 5.2.2 shows Canada's inventoried forest land divided into two gross merchantable volume classes: 1 to 75 m^3 per hectare, and over 75 m^3 per hectare. The forest land with a gross merchantable volume of greater than 75 m^3 per hectare corresponds approximately to Canada's managed forest.

Total gross merchantable volume, or growing stock, in a province is obtained by multiplying the area of the timber-productive forest by the gross merchantable volume per hectare. Growing stock by province for the managed forest is shown in Figure 5.2.2 and Table 5.2.2.

1. Haddon, B.D., 1988, *Forest Inventory Terms in Canada*, Forestry Canada.

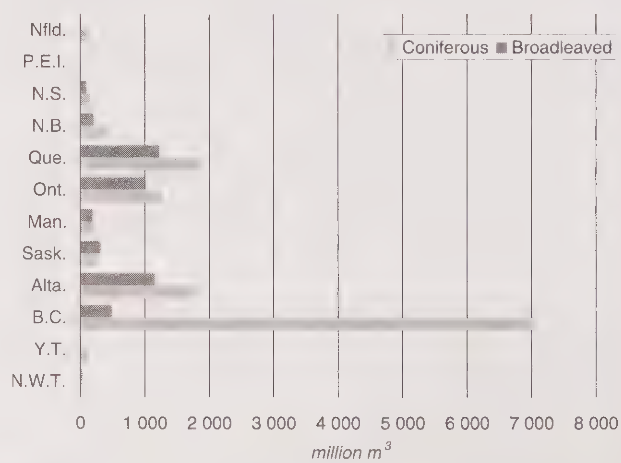
5.2.2 Timber harvesting

When timber is extracted from the forest, it is generally referred to as 'roundwood.' As the name suggests, roundwood consists of trees, with or without bark, less their branches, tops and stumps.

Roundwood includes more specific products such as logs, bolts, pulpwood, posts, pilings, and other 'in the round' industrial wood. Logs and bolts are used as raw material in the manufacture of lumber, plywood and similar products. Bolts are also used in the manufacture of shingles and shakes. Pulpwood is used to produce pulp for paper making.

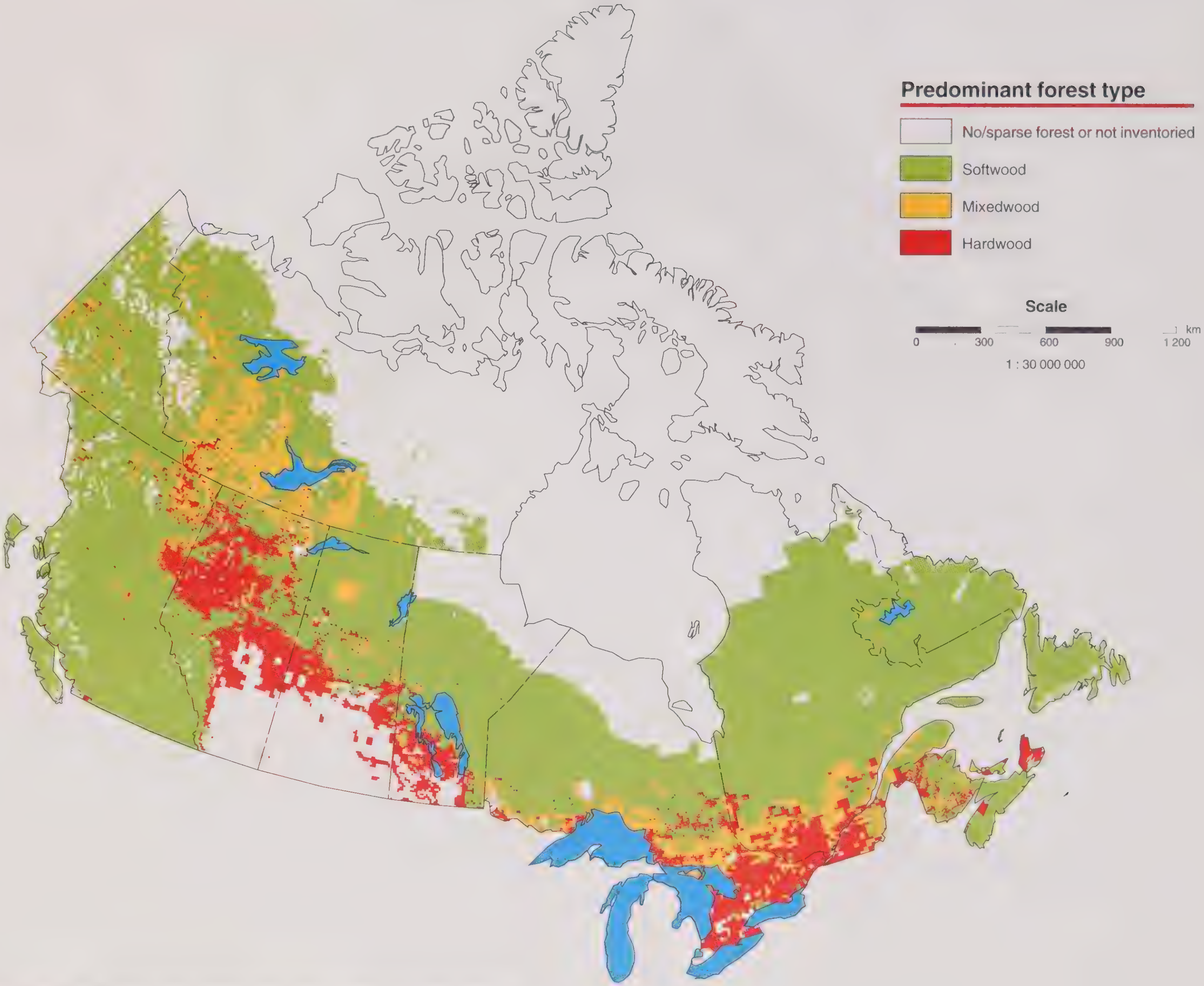
The annual volume of coniferous and broadleaved roundwood harvested nationally between 1970 and 1997 is

Figure 5.2.2
Growing Stock by Province and Territory, 1994



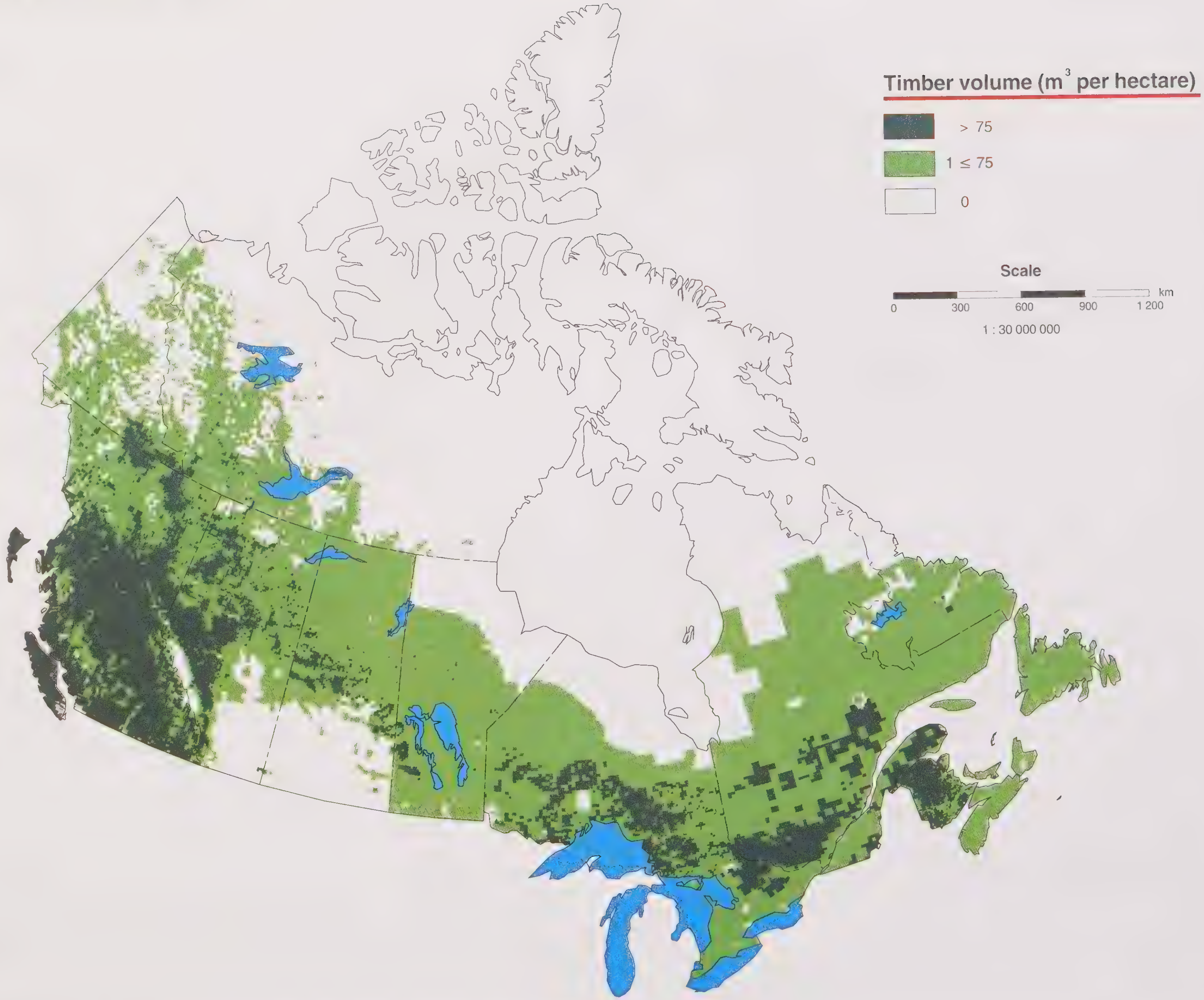
Source:
Lowe, J. J., K. Power and S.L. Gray, 1994, *Canada's Forest Inventory (1994 Version)*, Natural Resources Canada, Canadian Forest Service, Victoria.

Map 5.2.1
Forest Type, 1994



Source:
Lowe, J. J., K. Power and S.L. Gray, 1994. *Canada's Forest Inventory (1994 Version)*. Natural Resources Canada, Canadian Forest Service, Victoria.

Map 5.2.2
Timber Volume, All Species, 1994



Source:
Lowe, J. J., K. Power and S.L. Gray, 1994, *Canada's Forest Inventory (1994 Version)*, Natural Resources Canada, Canadian Forest Service, Victoria.

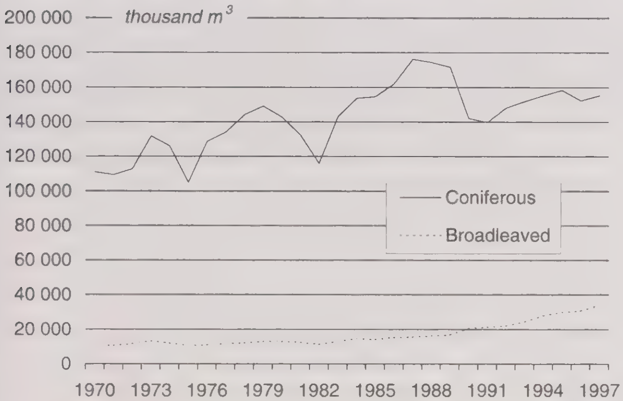
Table 5.2.2
Volume of Managed Forest by Province and Territory, 1997

Province/Territory	Growing stock Coniferous	Growing stock Broadleaved	Roundwood harvested Coniferous	Roundwood harvested Broadleaved	Total	Annual allowable cut[1]	AAC utilization[2]
	thousand m^3						percent
Newfoundland	170 228	22 437	2 409	150	2 559	2 642	96.86
Prince Edward Island	15 999	10 025	434	123	557	491	113.44
Nova Scotia	152 618	101 183	6 190	799	6 989	5 275	132.49
New Brunswick	427 734	209 452	7 668	3 585	11 253	11 144	100.98
Quebec	1 859 189	1 228 516	32 653	9 794	42 447	58 810	72.18
Ontario	1 255 757	997 602	19 609	6 986	26 595	36 429[3]	68.23
Manitoba	214 463	196 844	1 583	599	2 182	9 726	22.43
Saskatchewan	249 674	318 665	2 718	1 486	4 204	7 570	55.54
Alberta	1 788 471	1 160 565	14 482	7 745	22 227	23 988	92.66
British Columbia	7 017 028	490 299	66 904	2 393	69 297	71 559	96.84
Yukon Territory	132 365	18 101	423	-	423	459	92.16
Northwest Territories	58 943	32 735	178	-	178	236	75.42

Notes:
1. The annual allowable cut in each province or territory is set for a different period: Nfld.: 1994-2015; P.E.I.: 1992-2002; N.S.: 1991-1997; N.B.: 1997-2002; Que.: 1994-1999; Ont.: 1995; Man.: 1997; Sask.: 1990-2080; Alta.: 1997: B.C.: 1997; Yukon: 1996; N.W.T.: 1995-1996. Annual allowable cut is measured in net merchantable volume for all provinces and territories except for P.E.I., where it is measured in gross merchantable volume.
2. AAC utilization is the ratio of total volume harvested to annual allowable cut.
3. Rather than an annual allowable cut, Ontario calculates a 'maximum allowable depletion' (MAD), which is measured in hectares. In this table, MAD has been converted to an equivalent AAC by assuming an average of 100 m^3 of net merchantable volume per hectare.

Sources:
Canadian Council of Forest Ministers, *Compendium of Canadian Forestry Statistics 1998: National Forestry Database Program*, Natural Resources Canada, Canadian Forest Service, <http://nfdp.ccfm.org>, (accessed December 5, 1999).
Lowe, J.J., K. Power and S.L. Gray, 1994, *Canada's Forest Inventory (1994 Version)*, Natural Resources Canada, Canadian Forest Service, Victoria.

Figure 5.2.3
Roundwood Volume Harvested, 1970-1997



Source:
Canadian Council of Forest Ministers, *Compendium of Canadian Forestry Statistics 1998: National Forestry Database Program*, Natural Resources Canada, Canadian Forest Service, <http://nfdp.ccfm.org>, (accessed December 5, 1999).

shown in Figure 5.2.3. As can be seen, the general trend in harvest has been upward since 1970.

Figures 5.2.4 and 5.2.5 show harvest volumes for coniferous and broadleaved species by province and territory for 1997. British Columbia leads in the production of coniferous roundwood by a factor of two as compared with Quebec and Ontario.

British Columbia's roundwood production is predominantly coniferous (Table 5.2.2) and is used mainly for the manufacture of lumber. An important by-product of the British Columbia sawmilling industry is wood chips, used in the pulp and paper industry.

Figures 5.2.4 and 5.2.5 show that approximately ten times as much coniferous as broadleaved volume was harvested in 1997. Recent technological developments enable, for the first time, the use of broadleaved species as a major source of pulpwood. As a result, harvesting of the northern broadleaved species in Alberta and Quebec has taken off in the last 10 years. Before this, broadleaved species were considered largely undesirable from the pulp and paper industry's perspective. Their growth was inhibited to allow for the unhindered growth of coniferous species.

5.2.3 Forest management

As is the general case with natural resources, forests are managed from a legal perspective by provincial and territorial legislation. Moreover, since most of the managed forest is publicly owned, these governments also play an important role in the active management of forest land. Major elements of this role involve setting annual allowable cut levels and fighting forest fires.

Annual allowable cut

Through tenure arrangements, rights are given to forestry companies by governments to harvest a specified volume of timber—or annual allowable cut (AAC)—on a defined area of forest land for a specified period of time. Figure 5.2.6 presents average AAC figures by province for the period 1991-1997.

Figure 5.2.4
Coniferous Volume Harvested by Province and Territory, 1997

Source:
Canadian Council of Forest Ministers, *Compendium of Canadian Forestry Statistics 1998: National Forestry Database Program*, Natural Resources Canada, Canadian Forest Service, <http://nfdp.ccfm.org>, (accessed December 5, 1999).

Figure 5.2.5
Broadleaved Volume Harvested by Province and Territory, 1997

Source:
Canadian Council of Forest Ministers, *Compendium of Canadian Forestry Statistics 1998: National Forestry Database Program*, Natural Resources Canada, Canadian Forest Service, <http://nfdp.ccfm.org>, (accessed December 5, 1999).

Tenures are usually associated with a specific wood processing facility, such as a lumber or pulp mill. They vary in size and duration, depending on the complexity and size of the processing facility in question. Large tenures tend to go to vertically integrated facilities—those that carry out all of the steps in harvesting and processing themselves—and can run for 25 years, ensuring a stable supply of raw material.

AACs regulate harvest levels with the objective of achieving sustainability in the long term. The methods used to determine AACs are complex and vary from province to province. A number of factors are considered, including accessibility of the forest land; tree growth rate; losses to fire, insects and disease; environmental constraints; and expectations of forest management programs. Most provincial AACs specify annual coniferous and broadleaved harvest volumes for five-year periods.[1]

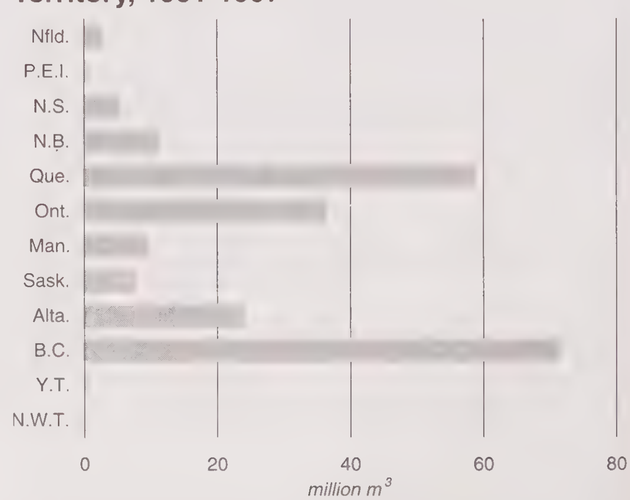
AAC utilization and harvest ratio

Two measures describing the extent to which the forest is used are AAC utilization and harvest ratio.

AAC utilization is defined as the timber volume harvested each year divided by the annual allowable cut. Figure 5.2.7 shows AAC utilization by province for 1997. Some provinces allow harvests to fluctuate over time, so that AAC utilization can exceed 100% occasionally. This is seen in Figure 5.2.7 for Nova Scotia and Prince Edward Island. In general, this fluctuation is balanced over the period for which the AAC is defined.

Harvest ratio is defined as the area harvested annually, expressed as a percentage of the managed forest. Figure 5.2.8 shows the harvest ratio for 1997. A ratio of 1% means that, other things being equal, the entire managed forest would be felled over a 100-year period. In general, this is a sufficiently long period to allow a harvested area to regenerate to maturity before it is harvested again.

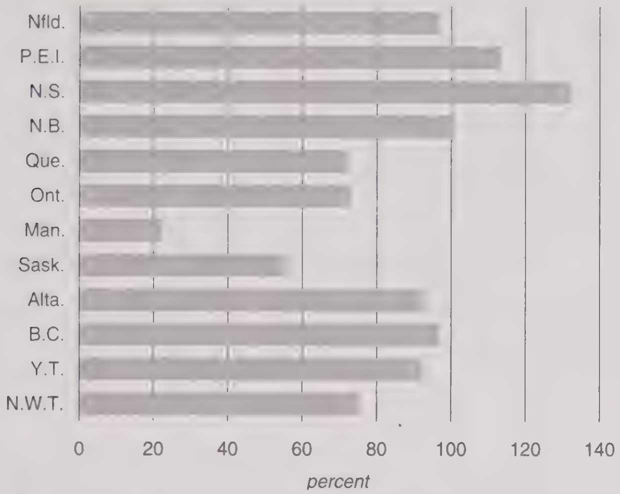
Figure 5.2.6
Annual Allowable Cut by Province and Territory, 1991-1997



Source:
Canadian Council of Forest Ministers, *Compendium of Canadian Forestry Statistics 1998: National Forestry Database Program*, Natural Resources Canada, Canadian Forest Service, <http://nfdp.ccfm.org>, (accessed December 5, 1999).

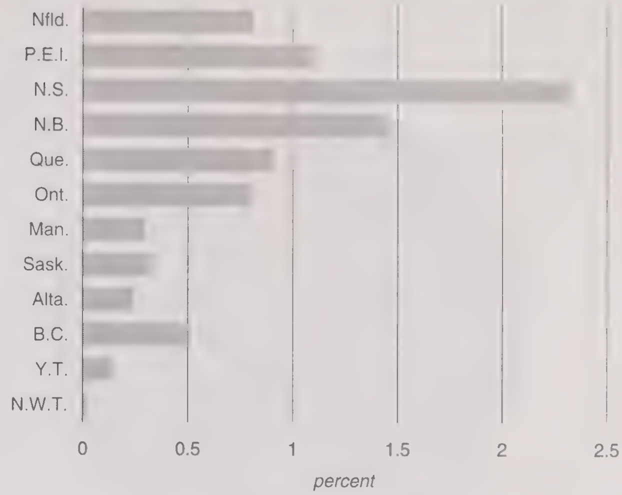
1. In Ontario the term 'maximum allowable depletion' (MAD) is used in place of AAC. MAD is specified in area rather than volume.

Figure 5.2.7
Annual Allowable Cut Utilization by Province and Territory, 1997



Source:
Statistics Canada, Environment Accounts and Statistics Division.

Figure 5.2.8
Harvest Ratio by Province and Territory, 1997



Source:
Statistics Canada, Environment Accounts and Statistics Division.

Note that harvest ratio figures do not include losses in the forest from causes other than harvesting, such as pest infestation and forest fires. Thus, they represent a lower bound on the share of the managed forest from which commercial timber is removed or lost annually. On the other hand, the figures do not account for the fact that harvesting activities can expand onto currently inaccessible land if the managed forest is insufficient to support future harvest levels.

The four largest timber-producing provinces had harvest ratios of less than 1% in 1995. Nova Scotia, New Brunswick and Prince Edward Island had ratios of between 1% and 2.5%.

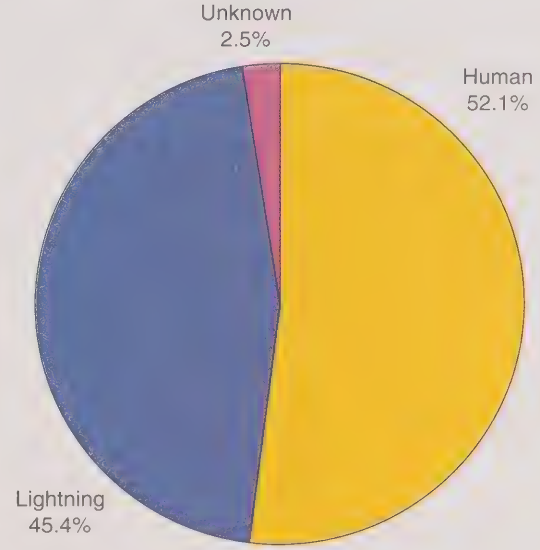
Forest fires

Forest fire management policies attempt to balance fire suppression costs against factors such as human safety and loss of valuable timber. More and more, they also recognize the natural role that fire plays in forest regeneration. In the boreal forest, for example, coniferous species such as jack pine require fire to reproduce.

From 1990 to 1997, 91% of forest fires were suppressed to some extent and were kept to less than 10 hectares in size. These numerous small fires accounted for only 0.3% of the total area burned. At the other end of the spectrum, the 1.9% of fires that exceeded 1 000 hectares accounted for about 96% of the total area burned.

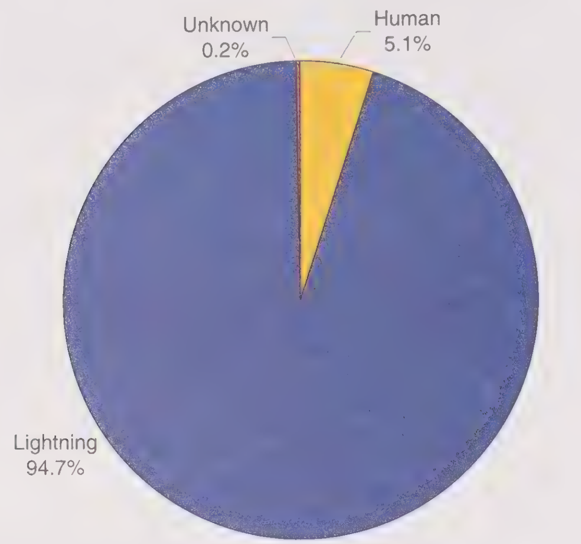
Figure 5.2.9 indicates that people were responsible for starting a greater number of fires than were natural causes (lightning) during this period. Despite this, fires started by lightning burned on average more than 15 times the area of those ignited by human activity (Figure 5.2.10). This is primarily due to the location of the fires started by people. Generally, these fires burn in southern Canada where man-made obstacles (such as highways) limit the spread of the fire and where the risk to people requires a more significant and rapid suppression response. Without such suppression, a larger area of forest would be burned by human-caused fires.

Figure 5.2.9
Forest Fires by Cause, 1990-1997



Source:
Canadian Council of Forest Ministers, *Compendium of Canadian Forestry Statistics 1998 National Forestry Database Program*, Natural Resources Canada, Canadian Forest Service, <http://nfdp.ccfm.org>, (accessed December 5, 1999).

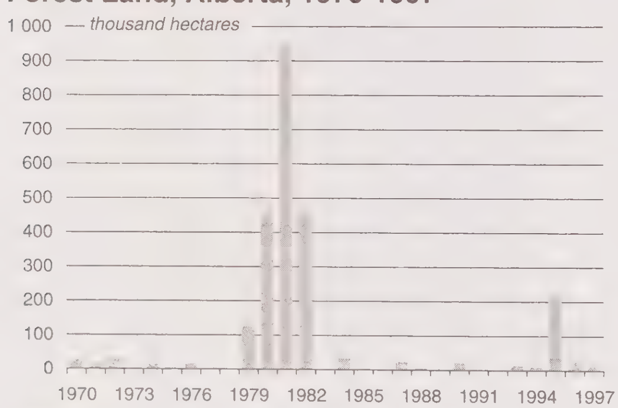
Figure 5.2.10
Area Burned by Cause, 1990-1997



Source:
Canadian Council of Forest Ministers, *Compendium of Canadian Forestry Statistics 1998: National Forestry Database Program*, Natural Resources Canada, Canadian Forest Service, <http://nfdp.ccfm.org>, (accessed December 5, 1999).

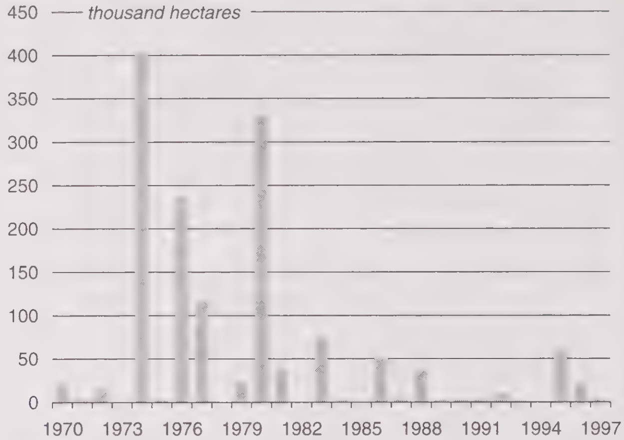
Forest fires vary greatly in size and frequency. British Columbia's wet climate limits the impact of fire in that province. Fire is a problem in drier Alberta, Ontario and Quebec, however, where it can have a significant impact on timber supply (Figures 5.2.11 to 5.2.13). Catastrophic forest fires such as those that occurred in Quebec in 1989 (2.1 million hectares) and in Alberta in 1981 (1 million hectares) significantly alter the age-class structure of the forest and its future development. They are thus an important factor in the calculation of future timber supply.

Figure 5.2.11
Area Burned–Stocked Timber-productive Forest Land, Alberta, 1970-1997



Source:
Canadian Council of Forest Ministers, *Compendium of Canadian Forestry Statistics 1998: National Forestry Database Program*, Natural Resources Canada, Canadian Forest Service, <http://nfdp.ccfm.org>, (accessed December 5, 1999).

Figure 5.2.12
Area Burned–Stocked Timber-productive Forest Land, Ontario, 1970-1997

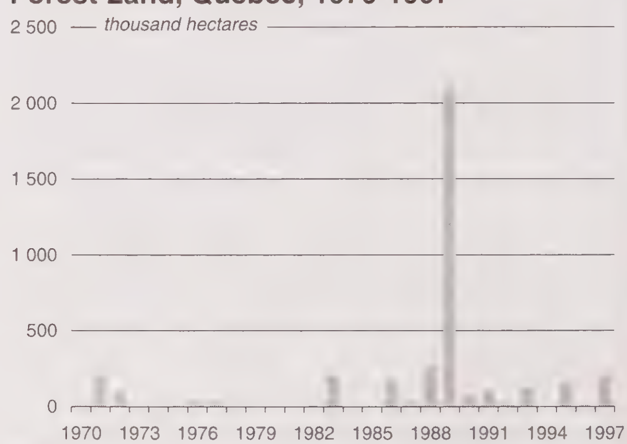


Source:
Canadian Council of Forest Ministers, *Compendium of Canadian Forestry Statistics 1998: National Forestry Database Program*, Natural Resources Canada, Canadian Forest Service, <http://nfdp.ccfm.org>, (accessed December 5, 1999).

Alberta experienced a period of major fire losses between 1980 and 1983, including the catastrophic fire of 1981 (Figure 5.2.11). Although the fire rate has declined in recent decades in Ontario, the reverse is the case in Quebec (Figures 5.2.12 and 5.2.13). The 2.1 million-hectare Quebec fire in 1989 dwarfed the province's historical annual fire rate.

The fire data reported in figures 5.2.11 to 5.2.13 apply to the entire stocked, timber-productive forest, including that which is inaccessible and reserved. The area of the managed forest actually burned was smaller than indicated in these figures.

Figure 5.2.13
Area Burned–Stocked Timber-productive Forest Land, Quebec, 1970-1997



Source:
Canadian Council of Forest Ministers, *Compendium of Canadian Forestry Statistics 1998: National Forestry Database Program*, Natural Resources Canada, Canadian Forest Service, <http://nfdp.ccfm.org>, (accessed December 5, 1999).

Forest certification

The linking of environmental performance to the product market has been attempted through certain forest certification programs, such as those developed by the Canadian Standards Association and the Forest Stewardship Council. These programs enable certified forest companies to label their products as having been produced in an environmentally appropriate manner. Certain export markets for Canadian timber demand only certified timber products.

Emerging management approaches

In response to environmental concerns associated with traditional forest management, new approaches have emerged in the last decade. Two of these are multiple-use management and the 'ecosystem approach.'

Timber harvesting generates environmental impacts not accounted for by the market system. These include impacts on wildlife habitat, air and water quality, aesthetics and recreational access. Multiple-use management seeks to examine these elements together with traditional objectives. The benefits from timber harvesting would be weighed against its non-timber benefits in a search for management approaches that maximize the sum of all net benefits.

The ecosystem approach rests on the notion that human disturbances to forests should mimic natural disturbances such as fire, insect infestations, floods and windstorms. This, it is thought, is the best way to ensure the health and sustainability of forests. Alberta's forest management plan has recently recognized that an ecosystem approach is a necessary and sufficient condition for sustainable forest management.[1]

The ecosystem approach has also been criticized for not including the social consensus implicit in legislated objectives and for imposing an arbitrary, 'desired' state of the forest about which society has little to say.[2]

1. Government of Alberta, 1997, *Interim Forest Management Planning Manual–Guidelines to Plan Development,* Land and Forest Service, Edmonton.
2. Sedjo, R., 1995, "Ecosystem Management: An Uncharted Path for Public Forests," in *Resources*, Vol. 10, pp. 18-20.

5.3 Marine resources

5.3.1 Marine fish stocks

A marine fish stock is defined as the population of a given species of fish or shellfish found at a certain point in time within a defined area of ocean. Assessment of the size of a fish stock is not always straightforward. Many different parameters must be measured, including age distribution of the fish in the stock, the number of young fish that enter the stock each year (recruitment), growth rates, fish mortality resulting from fishing and natural causes, and fishing effort. Obtaining reliable data for all these parameters is costly and time-consuming, in part because data from different sources are sometimes difficult to reconcile.

Although the size of most fish stocks supporting a commercial fishery is assessed in most years, the difficulty in obtaining reliable data means that the quality of these assessments varies significantly. Moreover, fish stocks that are not fished intensively are generally not assessed, since natural mortality outweighs fishing mortality by a large margin. Thus, it is not possible to present stock estimates for each of the commercial species targeted in Canadian waters. What follow are summaries of the stock assessments for some of Canada's most important commercial fish stocks.

Atlantic cod stocks

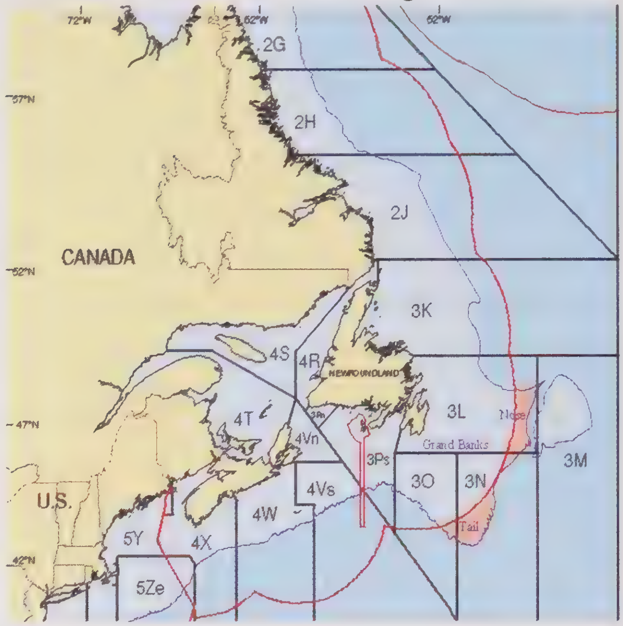
Cod stocks in the northwestern Atlantic Ocean are grouped into fishing divisions under a Northwest Atlantic Fisheries Organization (NAFO) convention (Map 5.3.1). Among these are the Southern Gulf of St. Lawrence (4TVn), and Northern (2J3KL) and Eastern Scotian Shelf (4VsW) areas. The stock status in each of these areas is discussed below.

Southern Gulf of St. Lawrence cod

Table 5.3.1 shows the estimated spawning biomass[1] of Southern Gulf of St. Lawrence (4TVn) cod from 1950 to 1997. The estimated spawning biomass of cod in this area fell by about 81% between 1956 and 1976. This decline was most likely due to high fishing effort.[2] The Canadian mobile-gear fleet developed toward the end of this period, while pressure from foreign fishers was high during the early part of the period. Recruitment and growth were about average over the period, suggesting that natural mortality did not play an important role in the decline.

1. Spawning biomass refers to the portion of a fish stock that is sexually mature in the spring of the year and that migrates inshore to the spawning beds to reproduce.
2. Alan Sinclair, Department of Fisheries and Oceans, personal communication.

Map 5.3.1
Northwestern Atlantic Fishing Areas



Note:
200-mile fishing zone and NAFO fishing boundaries.
Source:
Department of Fisheries and Oceans.

Several factors contributed to a rapid increase in the spawning biomass in the late 1970s. The most important was the reduced rate of fishing brought about by the establishment of a total allowable catch (Text Box 5.3.1) in 1974 and the declaration of Canada's 200-mile fishing zone in 1977 (Text Box 5.3.2). Also important were very successful year-classes[3] in 1974–75 and 1979–80, that provided the young fish recruited to the fishery (that is, the fish that joined the adult population) in the late 1970s and early 1980s. Cod also experienced above-average growth rates in the late 1970s.

Beginning in 1987, the spawning biomass of Southern Gulf of St. Lawrence cod declined consistently, reaching its lowest recorded level (66 000 tonnes) in 1993 (Table 5.3.1). Intense harvesting by all fleets, combined with a decrease in natural production, brought about this decline.

Since closure of the fishery in 1992, stocks in the Southern Gulf of St. Lawrence have increased only slightly. Natural mortality increased significantly from historic levels in the late 1980s and early 1990s. Recruitment to the fishery in this period was very low as a result. Unless this situation improves, the stock may decline further even in the absence of a fishery.[4]

3. Year-class is the term used for all the fish of a particular species born in a particular fishery area during a season.
4. Department of Fisheries and Oceans, 1998, *Cod in the Southern Gulf of St. Lawrence*, Stock Status Report A3-01(1998), Ottawa.

Text Box 5.3.1
Total Allowable Catch

Total allowable catch (TAC) is the maximum tonnage of a particular fish species that can be caught in a particular fishery during one fishing season. TAC is set by the Department of Fisheries and Oceans in consultation with those who work in the fishing industry.

TAC represents the global quota for a fish stock. To ensure that the sum of the catch by all fishers operating within the fishery does not exceed the TAC, the global quota is subdivided to provide fishers with predetermined shares of the total catch.

When the TAC for a given fishery is nearly reached, fishing effort can be reduced by setting limits on the allowable catch per fishing trip, by varying the times during which fishing is allowed and by restricting the types of fishing gear that can be used.

Once the TAC for a given fishery is reached, the fishing season is closed for that year.

Text Box 5.3.2
The 200-Mile Limit

In 1977, Canada extended its fisheries jurisdiction from 12 miles to 200 miles (see the red boundary on Map 5.3.1). Within this zone, Canadian fisheries patrol officers carry out at-sea inspections on both foreign and domestic fishing vessels. Officers also work on shore to enforce fisheries regulations. In the case of at-sea violations, fishing vessels are escorted to a Canadian port where the vessel and catch are seized and charges laid in a court of law. Penalties can be as high as $750 000 for foreign vessels, in addition to the value of the catch.

Eastern Scotian Shelf cod[1]

Just as in the Southern Gulf of St. Lawrence, cod stocks in the Eastern Scotian Shelf (4VsW) came under heavy fishing pressure throughout the 1960s and early 1970s. As can be seen in Table 5.3.1, the spawning biomass fell by 76% between 1963 and 1976. This was the result of excessive fishing, primarily by foreign vessels.

Following the imposition of the 200-mile limit in 1974, the spawning biomass increased substantially, reaching a peak of 217 000 tonnes in 1985. The Canadian offshore trawler fleet subsequently expanded its fishing effort and the spawning biomass declined considerably after 1987. In addition to pressure from fishers, a prolonged period of cool sea-bottom temperatures in the area may have contributed to the sharp stock decline after 1987.

Even with the moratorium imposed on the cod fishery in 1992, the stock does not appear to be recovering.

1. Department of Fisheries and Oceans, 1996, *Eastern Scotian Shelf Cod*, Stock Status Report 96/67E, Ottawa.

Table 5.3.1
Spawning Biomass of Selected Fish Stocks, 1950-1997

Year	Southern Gulf of St. Lawrence cod	Eastern Scotian Shelf cod	Pacific herring	Pacific halibut[1]
	thousand tonnes			
1950	242	..	..	.
1951	265	..	272	98
1952	313	..	254	99
1953	341	..	161	98
1954	362	..	268	100
1955	397	..	271	98
1956	420	..	311	99
1957	368	..	237	96
1958	317	123	120	92
1959	258	124	265	89
1960	228	120	235	86
1961	238	146	203	85
1962	257	151	234	83
1963	247	152	250	79
1964	193	152	265	75
1965	167	133	201	72
1966	139	105	123	68
1967	139	104	96	64
1968	151	113	37	62
1969	169	94	35	63
1970	183	111	98	61
1971	152	115	117	60
1972	137	96	137	61
1973	113	77	150	64
1974	92	52	202	73
1975	80	50	253	76
1976	78	36	255	79
1977	91	44	244	83
1978	152	75	227	89
1979	206	110	174	98
1980	228	118	188	108
1981	244	126	197	122
1982	245	145	200	135
1983	252	153	162	150
1984	261	179	145	164
1985	315	217	158	175
1986	368	208	181	184
1987	303	171	172	190
1988	250	123	199	201
1989	204	90	214	206
1990	161	65	224	212
1991	122	51	176	213
1992	90	40	234	213
1993	66	13	223	211
1994	69	13	179	206
1995	74	18	151	203
1996	78	16	169	204
1997	80	14	184	203

Note:
1. Pacific halibut is measured in terms of exploitable biomass: the maximum amount that can be caught without exceeding the legal minimum size limit.

Sources:
Department of Fisheries and Oceans, Stock Assessment Secretariat.
International Pacific Halibut Commission, Seattle, Washington.

Northern cod[1]

Perhaps the best known of Canada's cod fisheries, the northern cod (2J3KL) has traditionally been one of the largest cod stocks in the world. Until the mid-1950s, the northern cod fishery relied on small boats, lines, traps, and nets set inshore during spring and summer. At that time, foreign fishers were responsible for only a small portion of the total catch. The advent of large, year-round offshore trawlers in the mid-1950s introduced a significant change in this pattern. Foreign catches increased and the stock was placed under substantial pressure.[2] High catches in the 1960s and early 1970s resulted in stock declines until the mid-1970s.

Following the establishment of quotas in 1973 and the extension of Canada's jurisdiction to 200 miles in 1977, the spawning biomass increased until the mid-1980s. However, with the establishment of the TAC and the 200-mile fishing limit, the Canadian offshore fleet expanded. These offshore draggers, operating on a year-round basis, added to the pressure on the stock. Throughout the late 1980s the stock declined. A moratorium on the commercial fishery was imposed in July 1992.

The current stock size of northern cod is poorly quantified. However, it is clear that the overall stock size remains low relative to the levels of the 1980s and earlier. The prospects for offshore stocks, in particular, appear to be poor in the short and medium term. The spawning biomass has continued to decline despite the 1992 moratorium. The few cod that were hatched in the 1990s tended to die or be killed relatively quickly. Inshore stocks are more abundant, in some places appearing to have returned to levels seen before the moratorium. However, it is important to recognize that the inshore fishery will not return to its former level until offshore stock rebuilds and resumes its normal summer migration to the inshore.

The current crises in the health of groundfish stocks throughout Atlantic Canada have been attributed to a number of causes. The Department of Fisheries and Oceans has identified excessive harvesting as a major factor contributing to the groundfish decline and has indicated that environmental conditions and predator–prey relations were also contributing factors in certain areas. Overharvesting has been attributed to three main factors: fishing levels set above conservation standards; fishers catching more fish than allocated; and unsustainable fishing practices.[3]

1. Department of Fisheries and Oceans, 1999, *Northern Cod*, Stock Status Report A2-01(1999), Ottawa.
2. Mitchell, Bruce and Philip Dearden, 1998, *Environmental Change and Challenge: A Canadian Perspective*, Oxford University Press, Toronto.
3. Office of the Auditor General, 1997, *Report of the Auditor General*, Ottawa.

Status of Pacific Coast herring and halibut

Table 5.3.1 shows the spawning biomass of Pacific Coast herring from 1951 to 1997. As can be seen, the stock declined significantly beginning in 1965. By that time, nearly all major herring stocks had been discovered and most of the older fish had been caught.

In 1966, the commercial fishery collapsed when it could no longer be sustained. The spawning biomass fell from 265 000 to 123 000 tonnes between 1964 and 1966. This resulted in the closure of the commercial fishery for four years.[4]

The spawning biomass subsequently rebounded and remained high during the 1980s and 1990s. The commercial catch is no longer permitted to exceed 20% of each year's spawning biomass.

Estimating the spawning biomass of Pacific halibut is difficult. The International Pacific Halibut Commission (the agency responsible for managing this resource) estimates instead the 'exploitable' biomass. This is the quantity of halibut that can be caught by the commercial fishery without exceeding the legal minimum size limit. Trends in spawning biomass are similar to trends in exploitable biomass.[5]

Table 5.3.1 shows the exploitable biomass for Pacific halibut between 1951 and 1997. After declining in the 1950s and 1960s, the exploitable biomass increased dramatically, peaking at 213 000 tonnes in the early 1990s. Favourable environmental conditions and the introduction of quota systems in British Columbia and Alaska may have contributed to this increase.

5.3.2 Marine fish harvest

Table 5.3.2 illustrates landed catch and value by major species groups for all Canadian fisheries over the period 1989 to 1997. Several trends are worth noting in these figures.

First there is the marked divergence between total landed catch and total landed value over the period. At the same time that total marine landings decreased by 41%, landed value actually increased by 12%. From Table 5.3.2, it is apparent that the increase in landed value was due entirely to shellfish. Landed value of groundfish and pelagic fish declined significantly over the period, while landed value of shellfish increased by 95%. The increase in the landed value of shellfish was partly due to an increase of 36% in their landings. More important, though, were rising prices

4. Environment Canada, 1998, *Sustaining Marine Resources: Pacific Herring Fish Stocks*, SOE Bulletin No. 98-2, Winter, Ottawa.
5. Clark, William, International Halibut Commission, Seattle, Washington, personal communication.

for shellfish. From these figures, it is clear that the bright spot in the commercial fishery in recent years has been shellfish.

Atlantic Coast harvest

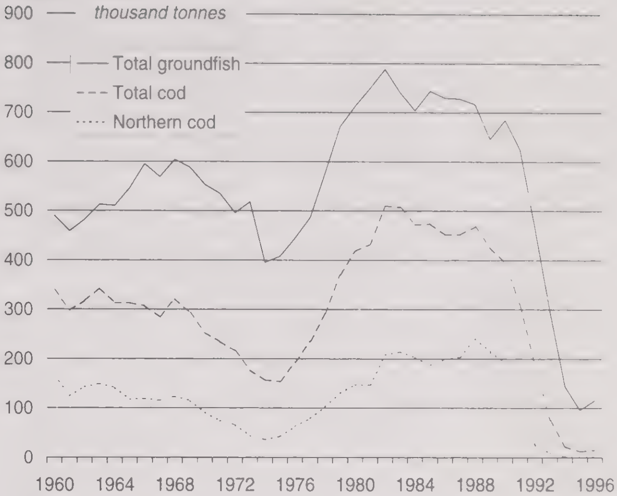
Looking at the fishery from a regional perspective, much the same story emerges. On the Atlantic Coast, total landings fell by 47% over the period 1989 to 1997, while total landed value increased by 18% (Table 5.3.3). Again, the explanation for this trend is found in the substantial increase (88%) in the value of shellfish landings.

Cod has traditionally been one of the most important species in the Atlantic fishery. Until recently, almost 50% of cod landings came from the northern cod stock off eastern Newfoundland and Labrador (Figure 5.3.1). Total cod landings fell by 55% between 1960 and 1975. The establishment of Canada's 200-mile jurisdiction in 1977 resulted in increased landings for Canadian fishers, which peaked at 510 000 tonnes in 1982. Landings decreased steadily after this and fell precipitously beginning in the late 1980s. In 1992, record-low stocks and concerns over the low abundance of the spawning stock led to a moratorium on fishing northern cod.

Other groundfish species have not experienced declines of the same magnitude as cod in Atlantic Canada. However, a general downward trend in groundfish landings and landed value can be noted between 1989 and 1997 (tables 5.3.5 and 5.3.6).

As already noted, the bright spot in the Atlantic fishery in recent years has been shellfish. Landings of shellfish rose by 39% between 1989 and 1997. Over the same period, landed shellfish value increased by an even larger 88%. The main factor explaining the increase in shellfish landings was favourable environmental conditions prevailing in the area, although increased fishing effort (driven by increased prices) and the opening of new fishing grounds may have been contributing factors.[1]

Figure 5.3.1
Atlantic Coast Groundfish Landings, 1960-1996



Source:
Department of Fisheries and Oceans, Statistical Services.

West Coast harvest

British Columbia's fishery has traditionally been dominated by salmon. In 1989, over 56% of the landed value on the West Coast came from salmon. Declines in landings during the 1990s lowered salmon's share of the total value to 27% by 1997. The decline in salmon landings has been attributed in part to habitat destruction stemming from logging activities, road construction, industrial pollution, agricultural run-off, and urbanization.

As on the East Coast, much of the loss in British Columbia's salmon fishery during this time was made up by large gains in the value of shellfish landings (152% from 1989 to 1997—Table 5.3.4).

Another important marine resource on Canada's Pacific Coast is herring, a fish highly valued for its roe. Landings declined dramatically from high levels in the early 1960s to record lows in the late 1960s. During this time, herring was processed into low-value products, such as fishmeal and oil. Since 1983, catches have not been permitted to exceed 20% of each stock's spawning biomass. This has resulted in stable landings in recent years.[2]

Contribution of aquaculture to commercial fishing

Aquaculture, the cultivation of fish in controlled environments, is rapidly gaining importance as a complement to the traditional fisheries.

Commercial aquaculture production dates back to the 1950s, when trout and oysters were the principal species produced. It was not until the 1980s, however, that commercial production really began to expand. In particular, salmon and mussel production has grown very rapidly in the last decade.

Table 5.3.7 shows aquaculture production from 1989 to 1997. As can be seen, the value of production of all species increased over that period: 40% for trout; 52% for oysters; 217% for salmon; and 229% for mussels.

1. Department of Fisheries and Oceans.

2. Environment Canada, 1998, *Sustaining Marine Resources: Pacific Herring Fish Stocks*, SOE Bulletin No. 98-2, Winter, Ottawa.

Table 5.3.2
Landed Catch and Value, 1989-1997

Year	Groundfish		Pelagic fish		Shellfish		Total[1]	
	Catch	Value	Catch	Value	Catch	Value	Catch	Value
	tonnes	million dollars	tonnes	million dollars	tonnes	million dollars	tonnes	million dollars
1989	816 115	431 914	493 086	412 244	249 004	548 638	1 605 087	1 413 388
1990	785 457	471 932	565 500	425 041	251 390	519 649	1 645 938	1 433 748
1991	786 715	497 336	434 878	295 186	251 363	583 199	1 509 033	1 393 949
1992	626 659	414 085	391 026	316 174	269 415	649 514	1 319 816	1 400 267
1993	428 806	297 168	420 749	364 538	288 307	730 932	1 163 188	1 422 505
1994	323 373	243 183	361 236	414 953	317 925	1 011 776	1 035 215	1 702 712
1995	230 122	224 405	312 093	239 684	308 510	1 269 756	880 290	1 770 412
1996	263 777	220 163	320 028	271 032	310 662	1 016 055	925 166	1 547 854
1997[2]	260 716	251 152	315 071	231 349	338 322	1 061 933	947 428	1 582 825

Notes:
1. Includes marine plants, lumpfish roe and miscellaneous other marine products.
2. Preliminary data.
Source:
Department of Fisheries and Oceans, Statistical Services.

Table 5.3.3
Landed Catch and Value, Atlantic Coast, 1989-1997

Year	Groundfish		Pelagic fish		Shellfish		Total[1]	
	Catch	Value	Catch	Value	Catch	Value	Catch	Value
	tonnes	million dollars	tonnes	million dollars	tonnes	million dollars	tonnes	million dollars
1989	684 504	359 161	359 393	85 414	227 816	503 531	1 317 902	959 775
1990	646 144	386 441	423 208	84 888	229 939	473 851	1 342 428	953 930
1991	624 178	396 411	305 897	71 098	226 993	536 920	1 192 446	1 013 768
1992	464 157	315 553	286 638	69 844	238 215	587 164	1 020 426	984 140
1993	293 735	196 010	293 025	90 419	260 689	653 259	872 290	957 709
1994	144 303	123 558	251 731	74 144	229 939	914 314	719 330	1 127 618
1995	95 866	106 968	232 173	86 326	279 150	1 150 358	636 465	1 357 869
1996	115 807	120 063	255 436	88 236	281 206	896 714	682 790	1 123 443
1997[2]	117 123	123 952	234 696	76 436	315 614	948 178	700 372	1 169 939

Notes:
1. Includes marine plants, lumpfish roe and miscellaneous other marine products.
2. Preliminary data.
Source:
Department of Fisheries and Oceans, Statistical Services.

Table 5.3.4
Landed Catch and Value, British Columbia Coast, 1989-1997

Year	Groundfish		Pelagic fish		Shellfish		Total[1]	
	Catch	Value	Catch	Value	Catch	Value	Catch	Value
	tonnes	million dollars	tonnes	million dollars	tonnes	million dollars	tonnes	million dollars
1989	131 611	72 753	133 693	326 830	21 188	45 107	287 185	453 613
1990	139 313	85 491	142 292	340 153	21 451	45 798	303 510	479 818
1991	162 537	100 925	128 981	224 088	24 370	46 279	316 587	380 181
1992	162 502	98 532	104 388	246 330	31 200	62 350	299 390	416 127
1993	135 071	101 158	127 724	274 119	27 618	77 673	290 898	464 796
1994	179 070	119 625	109 505	340 809	27 034	97 462	315 885	575 094
1995	134 256	117 437	79 920	153 358	29 360	119 398	243 825	412 543
1996	147 970	100 100	64 592	182 796	29 456	119 341	242 376	424 411
1997[2]	143 593	127 200	80 375	154 913	22 708	113 755	247 056	412 886

Notes:
1. Includes marine plants, lumpfish roe and miscellaneous other marine products.
2. Estimated data.
Source:
Department of Fisheries and Oceans, Statistical Services.

Table 5.3.5
Landed Catch by Species and by Province, 1989 and 1997

	Newfoundland		Nova Scotia		New Brunswick		Prince Edward Island		Quebec		British Columbia		Canada	
	1989	1997[1]	1989	1997[1]	1989	1997[1]	1989	1997[1]	1989	1997[1]	1989	1997[2]	1989	1997[1]
	tonnes live weight													
Groundfish														
Cod	262 083	12 286	122 860	14 515	10 490	960	4 729	264	25 928	1 581	9 143	1 537	435 233	31 142
Haddock	3 730	260	22 283	9 303	8	107	15	-	7	-	-	-	26 043	9 670
Redfish	15 980	6 444	31 373	11 707	3 650	22	8 795	-	16 354	28	24 456	18 400	100 608	36 600
Halibut	270	310	1 882	877	43	17	2	--	169	151	6 196	6 825	8 562	8 181
Flatfishes	48 258	1 507	14 012	6 714	2 605	467	1 795	809	3 625	1 296	6 475	4 300	76 770	15 092
Greenland turbot	12 227	13 565	108	670	125	29	-	-	4 723	2 146	609	2 901	17 792	19 312
Pollock	3 470	623	39 890	11 417	846	435	45	-	4	-	434	1 876	44 689	14 351
Hake	497	319	10 651	8 047	770	68	1 995	42	390	10	74 706	97 300	89 009	105 786
Cusk	-	1	3 402	1 777	2	-	-	-	-	-	-	-	3 404	1 778
Catfish	1 130	235	821	620	3	2	-	-	44	4	-	-	1 998	861
Skate	11	2 862	67	1 496	-	-	-	5	-	10	352	-	430	4 373
Dogfish	..	-	..	390	..	--	..	23	..	32	..	2 100	..	2 545
Other	5	925	2 355	1 660	26	62	3	9	26	15	9 592	8 354	12 007	11 025
Subtotal	**347 661**	**39 336**	**249 704**	**69 192**	**18 568**	**2 171**	**17 379**	**1 153**	**51 270**	**5 271**	**131 963**	**143 593**	**816 545**	**260 716**
Pelagic and other finfish														
Herring	30 581	20 753	84 027	76 848	107 208	65 252	4 151	15 830	3 272	5 751	40 795	31 539	270 034	215 972
Mackerel	6 016	1 188	5 228	4 125	4 237	1 976	3 065	6 693	2 253	5 769	-	183	20 799	19 935
Swordfish	..	42	..	1 007	..	-	..	-	..	-	..	-	..	1 049
Tuna	198	30	508	747	4	3	18	22	-	-	180	-	908	802
Alewife	-	-	5 019	274	6 032	2 697	132	107	-	--	-	-	11 183	3 078
Eel	84	72	32	20	326	37	77	44	364	112	-	-	883	284
Salmon	861	48	-	-	-	-	-	-	81	30	88 727	48 649	89 669	48 726
Smelt	47	7	40	16	1 133	697	104	162	140	343	--	-	1 464	1 224
Capelin	90 297	21 310	-	-	35	7	-	-	1 487	484	-	-	91 819	21 800
Other	156	123	1 565	1 712	432	12	35	260	70	89	3 639	4	5 897	2 200
Subtotal	**128 240**	**43 573**	**96 419**	**84 748**	**119 407**	**70 681**	**7 582**	**23 117**	**7 667**	**12 577**	**133 341**	**80 375**	**492 656**	**315 071**
Shellfish														
Clams/quahaug	1 443	15 361	10 132	10 449	1 551	630	814	1 596	620	1 270	7 690	2 957	22 250	32 263
Oyster	-	-	71	82	786	350	1 881	1 285	-	-	3 672	4 700	6 410	6 417
Scallop	674	12 154	79 964	46 990	8 357	2 497	757	1 773	2 436	2 331	75	73	92 263	65 818
Squid	3 102	12 720	58	17	-	-	-	2	-	-	-	6	3 160	12 746
Mussel	42	-	5	-	109	166	2 685	8 967	77	29	-	-	2 918	9 162
Lobster	3 118	2 175	19 089	18 741	9 193	7 103	9 354	8 096	3 203	2 827	-	-	43 957	38 941
Shrimp	26 203	39 174	4 946	16 860	2 925	3 903	-	-	9 586	12 980	3 119	4 960	46 779	77 877
Crab, queen	8 358	45 743	2 792	4 117	4 323	8 956	853	1 116	6 037	11 436	-	-	22 363	71 369
Crab, other	-	102	93	2 748	460	1 637	778	2 766	400	1 057	1 522	3 943	3 253	12 252
Sea urchin	..	869	..	719	..	1 727	..	30	..	159	..	5 200	..	8 704
Other	238	262	52	606	116	17	-	--	135	1 017	5 110	869	5 651	2 772
Subtotal	**43 178**	**128 560**	**117 202**	**101 329**	**27 820**	**26 986**	**17 122**	**25 631**	**22 494**	**33 107**	**21 188**	**22 708**	**249 004**	**338 322**
Other														
Marine plants	-	-	28 017	15 226	4	5 162	14 848	8 152	-	-	-	-	42 869	28 541
Lumpfish roe	2 728	2 498	-	-	-	-	-	-	-	22	-	-	2 728	2 519
Miscellaneous	166	1 500	143	-	247	199	-	-	36	180	693	380	1 285	2 259
Subtotal	**2 894**	**3 998**	**28 160**	**15 226**	**251**	**5 362**	**14 848**	**8 152**	**36**	**201**	**693**	**380**	**46 882**	**33 319**
Grand total	**521 973**	**215 467**	**491 485**	**270 496**	**166 046**	**105 200**	**56 931**	**58 053**	**81 467**	**51 156**	**287 185**	**247 056**	**1 605 087**	**947 428**

Notes:
1. Preliminary data.
2. Estimated data.

Source:
Department of Fisheries and Oceans, Statistical Services.

Table 5.3.6
Landed Value by Species and by Province, 1989 and 1997

	Newfoundland		Nova Scotia		New Brunswick		Prince Edward Island		Quebec		British Columbia		Canada	
	1989	1997[1]	1989	1997[1]	1989	1997[1]	1989	1997[1]	1989	1997[1]	1989	1997[2]	1989	1997[1]
	thousand dollars													
Groundfish														
Cod	119 948	10 866	77 948	20 784	5 353	1 324	2 057	240	14 427	1 557	4 519	3 000	224 252	37 771
Haddock	1 380	245	23 972	14 680	12	216	9	-	5	-	-	-	25 378	15 142
Redfish	4 734	2 836	9 463	6 929	1 128	4	2 226	-	4 443	14	14 993	27 000	36 987	36 784
Halibut	747	1 560	8 736	6 877	155	111	8	2	502	828	18 696	38 200	28 844	47 577
Flatfishes	19 638	924	14 090	10 359	1 697	399	1 130	735	2 521	883	4 871	4 500	43 947	17 800
Greenland turbot	7 614	15 090	69	1 761	78	60	-	-	4 521	3 439	116	500	12 398	20 851
Pollock	1 069	318	18 206	9 247	524	482	13	-	1	-	63	1 000	19 876	11 047
Hake	89	200	5 333	5 336	355	65	622	35	113	6	11 333	15 000	17 845	20 641
Cusk	-	1	1 836	1 728	1	-	-	-	-	-	-	-	1 837	1 730
Catfish	240	50	266	277	1	1	-	-	13	1	-	-	520	329
Skate	2	921	5	488	-	-	-	2	-	3	45	-	52	1 414
Dogfish	..	-	..	103	..	--	..	7	..	14	..	1 000	..	1 124
Other	2	567	1 812	1 350	7	20	1	2	46	4	18 162	37 000	20 030	38 943
Subtotal	**155 463**	**33 577**	**161 736**	**79 921**	**9 311**	**2 683**	**6 066**	**1 023**	**26 592**	**6 748**	**72 798**	**127 200**	**431 966**	**251 152**
Pelagic and other finfish														
Herring	3 573	3 157	12 297	10 156	14 253	11 126	553	2 796	587	975	67 609	45 300	98 872	73 509
Mackerel	963	207	1 682	2 418	1 288	1 099	892	3 898	643	2 621	-	3	5 468	10 246
Swordfish	..	29	..	8 563	..	-	..	-	..	-	..	-	..	8 592
Tuna	2 224	36	5 759	12 375	23	59	284	389	-	-	451	-	8 741	12 859
Alewife	-	-	2 572	137	1 464	840	43	43	-	--	-	-	4 079	1 019
Eel	308	446	95	1 857	1 052	662	212	241	1 237	735	-	-	2 904	3 941
Salmon	3 620	293	-	-	-	-	-	-	473	157	256 081	109 400	260 174	109 851
Smelt	39	5	68	43	794	714	91	260	186	158	1	-	1 179	1 181
Capelin	19 100	6 379	-	-	3	1	-	-	262	59	-	-	19 365	6 439
Other	311	60	7 461	2 721	659	49	11	123	325	550	2 643	210	11 410	3 712
Subtotal	**30 138**	**10 611**	**29 934**	**38 270**	**19 536**	**14 549**	**2 086**	**7 751**	**3 713**	**5 256**	**326 785**	**154 913**	**412 192**	**231 349**
Shellfish														
Clams/quahaug	433	20 408	7 477	8 506	2 128	1 172	1 521	3 112	667	1 358	20 178	34 500	32 404	69 056
Oyster	-	-	103	173	1 570	783	4 350	3 093	-	-	2 888	4 900	8 911	8 950
Scallop	661	19 156	79 268	66 610	9 513	5 557	897	4 209	2 777	4 368	315	364	93 431	100 264
Squid	719	3 283	21	11	-	-	-	--	-	-	-	8	740	3 303
Mussel	38	-	8	-	163	129	2 946	11 048	129	58	-	-	3 284	11 235
Lobster	17 933	22 616	138 902	207 399	44 381	63 312	45 967	73 823	18 798	29 232	-	-	265 981	396 383
Shrimp	45 378	108 228	12 572	44 751	3 629	5 637	-	-	13 119	23 159	9 900	33 700	84 598	215 475
Crab, queen	10 305	91 794	5 314	21 152	12 230	41 771	2 383	5 426	16 070	41 833	-	-	46 302	201 975
Crab, other	-	68	35	2 790	157	1 079	330	1 676	196	607	6 089	28 500	6 807	34 720
Sea urchin	..	1 160	..	1 926	..	3 987	..	52	..	244	..	9 900	..	17 270
Other	18	157	219	448	129	27	-	--	77	787	5 737	1 883	6 180	3 302
Subtotal	**75 485**	**266 871**	**243 919**	**353 766**	**73 900**	**123 454**	**58 394**	**102 441**	**51 833**	**101 647**	**45 107**	**113 755**	**548 638**	**1 061 933**
Other														
Marine plants	-	-	2 458	982	8	422	3 267	1 457	-	-	-	-	5 733	2 860
Lumpfish roe	4 263	11 651	-	-	-	-	-	-	-	96	-	-	4 263	11 746
Miscellaneous	1 010	6 027	157	-	447	288	-	-	59	451	8 923	17 018	10 596	23 784
Subtotal	**5 273**	**17 678**	**2 615**	**982**	**455**	**709**	**3 267**	**1 457**	**59**	**547**	**8 923**	**17 018**	**20 592**	**38 391**
Grand total	**266 359**	**328 737**	**438 204**	**472 938**	**103 202**	**141 396**	**69 813**	**112 671**	**82 197**	**114 198**	**453 613**	**412 886**	**1 413 388**	**1 582 825**

Notes:
1. Preliminary data.
2. Estimated data.

Source:
Department of Fisheries and Oceans, Statistical Services.

Table 5.3.7
Aquaculture Production, 1989-1997

	Trout		Oysters		Salmon		Mussels		Total[1]	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
	tonnes	thousand dollars	tonnes	thousand dollars	tonnes	thousand dollars	tonnes	thousand dollars	tonnes	thousand dollars
1989	3 888	22 655	6 489	9 015	16 276	102 018	3 391	4 148	30 263	139 137
1990	4 677	26 714	6 774	8 462	21 167	155 059	3 598	3 964	36 462	195 955
1991	4 660	24 127	6 218	6 287	29 001	220 159	4 046	4 981	44 567	257 087
1992	5 424	27 824	6 107	6 477	30 020	218 281	4 964	5 860	46 885	259 957
1993	5 670	29 637	6 528	6 773	32 523	244 957	5 175	5 802	50 375	289 274
1994	6 000	33 468	7 767	9 133	32 426	244 337	6 898	7 645	53 582	296 678
1995	5 326	26 317	7 735	9 718	42 515	286 852	8 626	9 891	66 296	342 076
1996	5 654	28 940	7 946	11 340	45 502	290 116	9 832	11 936	71 191	353 343
1997[2]	6 178	31 617	6 649	13 658	60 862	323 324	11 463	13 658	87 211	387 869

Notes:
1. Also includes char, cod, clams and scallops.
2. Preliminary data.

Source:
Department of Fisheries and Oceans, Statistical Services.

5.3.3 Management of marine resources[1]

The objective of fisheries management is to provide for long-term health of the resource and continued exploitation at sustainable levels. Canada pursues these by limiting access to the fisheries, establishing and monitoring quotas, and verifying compliance with our laws.

Limited entry

Most fisheries in Canada operate on a limited entry basis. This means that only those individuals who hold valid licences are allowed to fish. The number of licences issued is held constant so that a new fisher can enter the fishery only when an existing one gives up a licence.

Quotas

Quotas are set in terms of total allowable catch (Text Box 5.3.1). They specify the maximum amount of a given species that can be caught during a single season from a given stock.

In order to ensure that quotas are not exceeded, marine resource officers collect data on a daily basis from fishers returning to port and from vessels operating offshore.

Verifying compliance

Canada uses extensive air and sea surveillance to verify catch reports, detect unlicensed vessels, and check for unlicensed foreign vessels within the country's 200-mile fishing zone. In some cases, fisheries officials are actually present on offshore vessels during fishing trips to ensure compliance with Canadian regulations. Foreign vessels are obliged to accept an observer while in the Canadian 200-mile zone; domestic vessels must also allow an observer on board when requested to do so by fisheries authorities. Inspections of both foreign and domestic vessels are carried out at sea and in hundreds of ports by fisheries officials.

1. Department of Fisheries and Oceans, 1989, *Today's Atlantic Fisheries*, Ottawa.

5.4 Wildlife resources

In years gone by, wildlife represented a major source of food, clothing and income for fur traders, settlers and Native peoples. Although relatively few Canadians now depend on wildlife to satisfy these basic needs, it continues to play a role in the lives of most Canadians. Hunting and trapping, although declining in popularity, remain common activities in rural and northern communities. Images of wildlife adorn our art, our money and our coats of arms, and they play an important role in marketing our brand names. For millions of Canadians, observing wildlife is an enjoyable leisure time activity.

Despite the importance of wildlife to Canadians, our activities have significantly reduced some wildlife populations. Hunting by early European settlers was unregulated and, in some cases, excessive. Habitats have disappeared as land has been drained and cleared to make way for agriculture, forestry, urbanization and industrial development. Habitats have also been polluted, creating conditions under which many species can no longer live or reproduce.

Eight species of land mammals and birds are known to have disappeared from Canada since the arrival of European settlers, while 73 others are listed as endangered, threatened or vulnerable (see section 6.8–**Species at risk**). At the same time, populations of many species have stabilized in recent years as a result of wildlife management and habitat protection.

The importance of preserving wildlife is now firmly implanted in the public consciousness. While the impact of human progress on wildlife was rarely understood and considered in the past, the public and governments now demand that developers be sensitive to the consequences of their activities for native plants and animals.

5.4.1 Stocks of wildlife resources

With thousands of species scattered over millions of square kilometres, it is impossible for biologists to directly measure the size of all Canadian wildlife stocks. Instead, these scientists produce estimates using a number of indirect methods. The resulting data are often available only for selected species in certain regions.

Provincial or national population estimates are available primarily for widespread species with commercial or recreational importance. Wildlife managers use this information to adjust hunting and trapping regulations: if the population of a given species falls below a desired level, these activities are restricted to allow for increases in the population.

Big game

Deer, caribou, moose and bear are the most abundant and most commonly hunted big game in Canada (Table 5.4.1). Currently, stocks are sufficient to permit some degree of big game hunting in all provinces and territories, with the exception of Prince Edward Island where big game is not found.

Waterfowl

Waterfowl are the most economically important group of migratory birds. Ducks and geese, the most popular waterfowl for hunting, are found throughout Canada. Populations fluctuate dramatically from year to year because of weather and other factors, but populations of the major species have been increasing since the late 1980s. For example, in 1990, 8 of the 10 major species of ducks were below the target levels identified in the North American Waterfowl Management Plan (NAWMP).

Table 5.4.1
Big Game Stocks by Province and Territory, 1996

Province/Territory	Moose	Deer	Bear	Elk	Caribou	Antelope	Sheep	Goat
				number of animals				
Newfoundland	120 000	-	10 000	-	70 000[1]	-	-	-
Prince Edward Island	-	-	-	-	-	-	-	-
Nova Scotia	3 700	46 000	8 000	-	-	-	-	-
New Brunswick	28 000	135 000	20 000	-	-	-	-	-
Quebec	75 000	300 000	60 000	-	1 000 000	-	-	-
Ontario	130 000	350 000	85 000	..	..	-	-	-
Manitoba	31 000	150 000	28 000	8 000	..	-	-	-
Saskatchewan	..	..	..	..	..	..	-	-
Alberta	118 000	330 000	40 800	26 000	..	10 880	5 800	..
British Columbia	170 000	409 000	163 000	43 000	16 500	-	19 500	49 000
Yukon Territory	..	..	..	..	..	-	..	..
Northwest Territories	..	..	..	..	..	-	..	..

Notes:
Data are estimates obtained from provincial wildlife departments. Methods of estimation may vary by province.
1. This figure excludes caribou in Labrador. Caribou in the George River herd of northern Quebec and Labrador are included in the Quebec figure.
Source:
Statistics Canada, Environment Accounts and Statistics Division.

However, six years later, only 2 of the 10 species fell below these targets, while 8 met or surpassed them (Figure 5.4.1).[1]

Populations of several North American geese are at historically high levels. In the 1930s, the greater snow goose and Ross' goose were considered to be rare birds, with populations of a few thousand each. In 1998, the preliminary St. Lawrence Valley spring estimate for greater snow geese was 695 600, while the breeding population of Ross' geese in the Queen Maud Migratory Bird Sanctuary in the central Canadian Arctic was 982 000—a five-fold increase in only 10 years. The abundance of these and other Arctic-nesting white geese is causing degradation to habitats in the Arctic and along the St. Lawrence River and the Atlantic Coast, and agricultural damage in Quebec and the United States.[2]

Populations of 'giant' or 'resident' Canada geese have also been growing rapidly. These geese nest primarily in temperate regions such as southern Ontario and, if they migrate at all, spend winters in northern states such as Pennsylvania and New York. As well as being a potential nuisance in urban areas, their increasing numbers are a concern to farmers since these flocks feed heavily on food crops near their nesting areas. Meanwhile, wildlife managers are concerned with sharp declines in the numbers of migratory Canada geese that nest in arctic or sub-arctic regions—in particular the Atlantic and southern James Bay populations. Several years of poor habitat conditions, low recruitment from other populations, and high harvest rates are believed to be contributing to this decline.[3,4]

1. Canadian Wildlife Service Waterfowl Committee, 1998, *Status of Migratory Game Birds in Canada, November 2, 1998*, A. Filion and K.M. Dickson (eds.), Canadian Wildlife Service Unpublished Report, Ottawa.
2. *Ibid.*
3. *Ibid.*

5.4.2 Use of wildlife resources

Wildlife resources have both consumptive and non-consumptive uses. The majority of Canadians involved in wildlife-related activities participate in non-consumptive pursuits such as viewing, photographing and studying wildlife. According to a 1996 survey of adult Canadians (those over the age of 15), 4.4 million Canadians (18.6% of the adult population) made trips where these pursuits were the primary or secondary activities. As well, 9 million adults (38.3% of the adult population) participated in one or more of these activities around their home.[5]

Canadians consume wildlife mainly through hunting and trapping. In 1996, 1.2 million Canadian adults (5.1% of the adult population) spent an average of 17 days hunting for big game, small mammals, birds or waterfowl. In total they spent $1.3 billion on these activities. Big game was the most popular target: 61% of all hunters hunted for big game, 31% for birds other than waterfowl, 20% for waterfowl and 19% for small mammals.[6]

Big game hunting

From 1990 to 1996, the harvest of the most popular big game was fairly consistent (Table 5.4.2). Annual deer harvests ranged from 250 000 to 300 000; moose harvests were about 70 000 each year; and bear harvests were about 20 000. The number of licences sold in 1995 (Table 5.4.3) illustrates hunter demand for big game.

4. United States Fish and Wildlife Service, Office of Migratory Bird Management, *Geese*. <http://www.fws.gov/r9mbmo/mgmt/geese.html>, (accessed March 30, 1998).
5. Environment Canada, 1999, *The Importance of Nature to Canadians: Survey Highlights*, Catalogue No. En 47-311/1999E, Ottawa.
6. *Ibid.*

Table 5.4.2
Big Game[1] Harvested by Province and Territory, 1990-1996

Province/Territory	1990	1991	1992	1993	1994	1995	1996[2]
	number of animals						
Newfoundland	20 234	23 113	22 837	22 668	22 302	21 609	22 142
Prince Edward Island	...	...	...	...	...	...	
Nova Scotia	16 452	18 807	16 205	5 211	5 783	7 539	8 657
New Brunswick	14 225	14 747	14 305	13 402	13 670	14 761	15 268
Quebec	49 455	49 504	50 731	54 439	52 871	69 743	71 102
Ontario	70 954	73 310	63 531	62 158	67 350	82 341	60 636
Manitoba	28 921	34 700	29 326	33 035	36 547	41 655	39 869
Saskatchewan	59 742	69 397	75 760	78 456	69 633	72 506	59 795
Alberta	60 325	59 569	54 824	..	65 506	67 613	
British Columbia	63 983	63 435	65 745	51 683	51 151	49 972	
Yukon Territory	1 512	1 160	1 045	1 240	1 095	1 285	
Northwest Territories	..	..	..				

Notes:
1. Moose, deer, bear, elk, caribou, antelope, sheep and goat.
2. Preliminary data.
Source:
Statistics Canada, Environment Accounts and Statistics Division.

Figure 5.4.1
Population Indices[1] (with Standard Errors) for Major Duck Species in the Traditional Waterfowl Survey Area,[2] 1961-1998

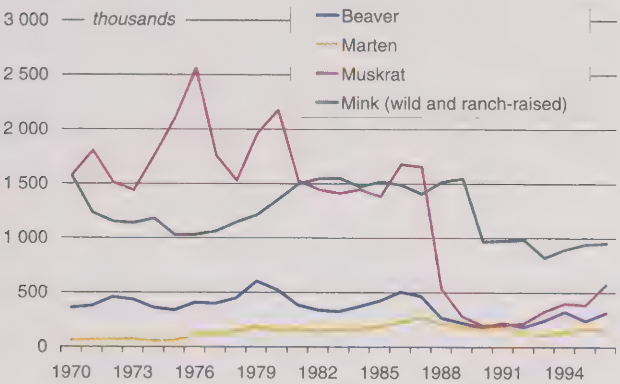
Notes:
The horizontal bars on each graph indicate the North American Waterfowl Management Plan (NAWMP) target population for each species.
1. The population index is not a population estimate; rather it bears a relationship to the true population size, the relationship being consistent from year to year.
2. Traditional spring air-ground waterfowl survey areas include the Canadian and U.S. prairies, the boreal forest from Ontario through to the Northwest Territories, and Alaska.
Source:
Canadian Wildlife Service Waterfowl Committee, 1998, *Status of Migratory Game Birds in Canada, November 2, 1998*, A. Filion and K.M. Dickson (eds.), Canadian Wildlife Service Unpublished Report, Ottawa.

Table 5.4.3
Big Game Licences Sold by Province and Territory, 1995

Province/Territory	Moose	Deer	Bear	Elk	Caribou	Antelope	Sheep	Goat
				number				
Newfoundland	25 703	...	3 376	...	3 800	...		
Prince Edward Island	...	...	...	..	...			
Nova Scotia	200	52 257	1 016	..	-			
New Brunswick	5 649	78 842	3 790	..	..	..		
Quebec	130 917	120 196	21 250	...	12 490			
Ontario	123 734	167 802	26 084	-	-			
Manitoba	6 475	54 375	3 543	2 878	429	...		
Saskatchewan	8 304	85 366	3 005	5 703	26	3 490	...	
Alberta	32 004	120 427	7 422	19 701	-	2 628	2 371	-
British Columbia	38 426	124 980	19 114	17 253	2 099	...	2 971	3 389
Yukon Territory	..	..	..	..	..	..		
Northwest Territories	..	..	..	..	..	..		

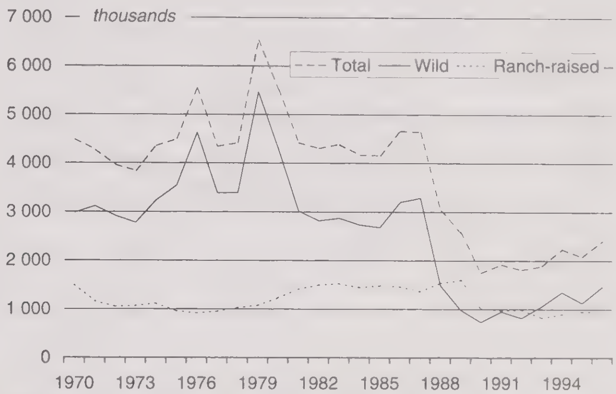
Source:
Statistics Canada, Environment Accounts and Statistics Division.

Figure 5.4.2
Pelts Harvested from Major Species, 1970-1996



Source:
Statistics Canada, Agriculture Division.

Figure 5.4.3
Wild vs. Ranch-raised Pelts Harvested, 1970-1996



Source:
Statistics Canada, Agriculture Division.

Trapping

The trapping of fur-bearing animals was an important industry during Canada's early history, attracting thousands of settlers and opening the country to exploration and commerce. In the last century, the industry has been declining in importance. This has been due primarily to a reduced demand for furs—the result of changes in fashion and public attitudes towards fur and wildlife in Canada and abroad. In the late 1980s, annual quantities and values of pelts harvested decreased dramatically (Figure 5.4.2). Production of both wild and ranch-raised pelts decreased, but the drop in wild pelts was much more pronounced (Figure 5.4.3). This can be attributed mainly to the plummeting production of muskrat pelts, the most common wild pelt harvested in Canada. From the late 1980s to the early 1990s, annual production of muskrat pelts dropped from over 2 million pelts, valued at $14 million, to about 200 000 pelts, worth less than half a million dollars. Production of muskrat pelts increased slightly through the 1990s, but remained far below the levels harvested before 1988.

Tables 5.4.4 and 5.4.5 show quantities and values of different pelts harvested in Canada. During the 1995–96 season, 1.47 million pelts, worth $34 million, were harvested from wild animals. Ranch-raised mink and fox accounted for a further 950 000 pelts, valued at $41 million. In terms of both dollars and numbers, mink is the most important fur-bearing species, accounting for two-fifths of all pelts harvested and more than half the total value. Few of these mink are trapped in the wild. In 1996, about 19 out of every 20 mink pelts harvested in Canada were ranch-raised, a proportion that has remained fairly constant for decades.

Waterfowl hunting

Mallard ducks and Canada geese are the most commonly hunted waterfowl in Canada and the United States. Figure 5.4.4 shows that while the harvest of Canada geese remained fairly stable between 1979 and 1997, the mallard duck harvest decreased steadily. Concern over falling prairie waterfowl populations, including mallard ducks,

Table 5.4.4
Pelts Harvested by Province and Territory, 1995-96

Species	Nfld.	P.E.I.	N.S.	N.B.	Que.	Ont.	Man.	Sask.	Alta.	B.C.	Y.T.	N.W.T.	Canada
							number						
Wild													
Badger	-	-	-	-	-	-	158	272	216	-	-	-	646
Bear	3	-	21	-	1 142	36	764	100	44	65	-	89	2 264
Beaver	3 471	564	8 642	14 779	71 000	90 275	34 007	39 145	46 623	5 220	471	3 468	317 665
Coyote	2	247	1 311	1 384	2 460	3 269	2 836	14 919	30 687	966	38	5	58 124
Ermine	1 973	14	1 037	641	11 380	4 828	2 734	3 873	5 326	2 722	79	442	35 049
Fisher	-	-	217	492	3 820	5 558	1 723	1 659	1 507	316	10	29	15 331
Fox	3 188	1 115	1 549	2 215	15 015	8 886	2 696	3 672	2 077	311	60	6 541	47 325
Lynx	49	-	-	-	83	734	95	724	1 365	717	305	1 083	5 155
Marten	751	-	-	2 156	27 575	46 057	19 084	4 247	10 171	24 368	5 713	9 243	149 365
Mink	2 998	401	2 168	1 158	6 215	9 379	5 649	3 752	1 030	927	139	1 201	35 017
Muskrat	1 555	4 485	36 834	29 878	87 774	124 857	119 579	112 462	34 973	2 880	1 445	18 374	575 096
Otter	1 031	-	765	634	4 296	7 974	1 875	1 175	341	406	12	37	18 546
Racoon	-	1 397	6 490	3 279	10 635	91 558	2 897	1 090	-	295	-	-	117 641
Skunk	-	6	229	34	204	130	-	13	16	2	-	-	634
Squirrel	1 498	64	6 890	600	6 829	2 326	6 882	15 995	32 660	4 363	973	676	79 756
Wildcat	-	-	976	199	-	8	-	11	7	119	-	-	1 320
Wolf	39	-	-	-	503	528	252	280	172	87	131	634	2 626
Wolverine	-	-	-	-	-	14	46	14	27	226	151	110	588
Other[1]	-	-	-	-	-	435	-	-	-	-	-	4 869	5 304
Total wild	**16 558**	**8 293**	**67 129**	**57 449**	**248 931**	**396 852**	**201 277**	**203 403**	**167 242**	**43 990**	**9 527**	**46 801**	**1 466 806**
Ranch-raised													
Fox	4 200	1 740	6 500	x	4 550	2 090	550	720	x	2 220	-	-	26 510
Mink	500	24 000	284 500	x	53 000	319 000	36 600	-	x	142 000	-	-	922 300
Total ranch-raised	**4 700**	**25 740**	**291 000**	**15 360**	**57 550**	**321 090**	**37 150**	**720**	**51 280**	**144 220**	**-**	**-**	**948 810**
Total pelts	**21 258**	**34 033**	**358 129**	**72 809**	**306 481**	**717 942**	**238 427**	**204 123**	**218 522**	**188 210**	**9 527**	**46 801**	**2 416 262**

Note:
1. Includes hair seals and other fur-bearing animals.
Source:
Statistics Canada, Agriculture Division.

Table 5.4.5
Value of Pelts Harvested by Province and Territory, 1995-96

Species	Nfld.	P.E.I.	N.S.	N.B.	Que.	Ont.	Man.	Sask.	Alta.	B.C.	Y.T.	N.W.T.	Canada
							dollars						
Wild													
Badger	-	-	-	-	-	-	3 792	6 785	5 117	-	-	-	15 694
Bear	228	-	2 083	-	92 497	2 812	63 412	8 637	4 242	7 805	-	62 407	181 716
Beaver	131 794	25 304	371 606	521 846	2 904 610	3 550 516	1 224 252	1 285 857	1 744 166	183 118	18 840	100 590	12 062 499
Coyote	72	8 411	43 447	38 558	79 187	95 389	104 932	499 784	1 186 359	29 415	1 482	183	2 087 219
Ermine	10 615	75	5 901	2 654	58 152	24 478	10 936	20 611	35 844	17 094	458	1 793	188 611
Fisher	-	-	10 121	23 134	213 882	304 245	105 103	83 598	92 470	17 405	660	1 539	852 157
Fox	79 719	37 499	39 639	49 262	408 188	222 355	67 280	63 857	40 261	6 111	1 800	196 993	1 212 964
Lynx	5 219	-	-	-	8 615	70 523	9 405	74 772	156 566	83 043	33 245	107 600	548 988
Marten	42 048	-	-	76 818	1 516 901	2 461 747	1 125 956	217 966	609 853	1 341 215	371 345	599 004	8 362 853
Mink	71 862	9 457	41 387	22 940	134 058	233 068	152 523	87 729	23 360	19 356	3 892	39 662	839 294
Muskrat	8 039	34 632	260 048	160 146	464 324	750 391	597 895	474 849	135 695	12 586	7 659	66 141	2 972 405
Otter	66 551	-	55 401	36 468	275 030	512 648	135 000	68 457	21 050	23 962	876	1 674	1 197 117
Racoon	-	31 828	155 565	68 400	232 268	2 348 463	55 043	21 695	-	4 688	-	-	2 917 950
Skunk	-	19	916	153	738	636	-	40	79	6	-	-	2 587
Squirrel	3 415	46	16 674	690	12 292	3 884	10 323	29 899	89 815	11 824	2 043	1 069	181 974
Wildcat	-	-	75 113	12 020	-	468	-	813	563	7 379	-	-	96 356
Wolf	6 116	-	-	-	67 442	39 431	34 020	42 117	18 815	9 033	31 964	162 859	411 797
Wolverine	-	-	-	-	-	5 066	15 962	3 427	10 816	75 556	49 981	31 541	192 349
Other[1]	-	-	-	-	-	835	-	-	-	-	-	153 204	154 039
Total wild	**425 678**	**147 271**	**1 077 901**	**1 013 089**	**6 468 184**	**10 626 955**	**3 715 834**	**2 990 893**	**4 175 071**	**1 849 596**	**524 245**	**1 526 259**	**34 462 875**
Ranch-raised													
Fox	310 683	128 851	466 935	x	314 588	150 175	40 710	44 255	x	126 809	-	-	1 868 872
Mink	21 598	1 005 905	12 353 536	x	2 235 147	13 447 234	1 602 703	-	x	6 161 869	-	-	39 396 384
Total ranch-raised	**332 281**	**1 134 756**	**12 820 471**	**761 417**	**2 549 735**	**13 597 409**	**1 643 413**	**44 255**	**2 092 841**	**6 288 678**	**-**	**-**	**41 265 256**
Total pelts	**757 959**	**1 282 027**	**13 898 372**	**1 774 506**	**9 017 919**	**24 224 364**	**5 359 247**	**3 035 148**	**6 267 912**	**8 138 274**	**524 245**	**1 526 259**	**75 806 232**

Note:
1. Includes hair seals and other fur-bearing animals.
Source:
Statistics Canada, Agriculture Division.

prompted Canada and the United States to initiate restrictive hunting regulations in 1985 and to tighten them further in 1988. By 1994 the population of mallards had increased sufficiently for these regulations to be relaxed.[1]

5.4.3 Wildlife management

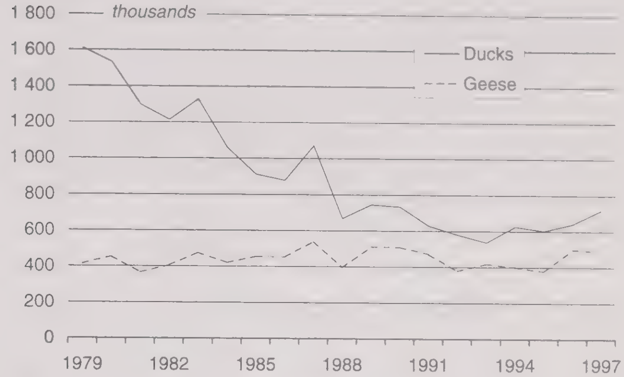
The most basic objective of wildlife management is to preserve the diversity of wildlife species. In order to maintain and to enhance wildlife populations, wildlife managers strive to improve the quality and quantity of wildlife habitats and to ensure that all uses of wildlife are sustainable. In addition, they aim to provide opportunities for public use and enjoyment of wildlife, while trying to reduce the risks and damage to wildlife from people's activities, and to people from wildlife.

Federal and provincial governments share the management of Canadian wildlife. The federal government is responsible for wildlife issues of national and international importance, such as international trade in wildlife and the protection and management of migratory birds, nationally significant habitat and endangered species.[2] Provincial governments administer hunting and trapping regulations and are responsible for the management of big game, small mammals and upland birds.

The purpose of hunting and trapping regulations is to keep harvests at levels that can be replaced with naturally reproducing wild populations. To achieve this goal, wildlife managers regulate several aspects of hunting and trapping: numbers of licences sold; limits on the size, number and sex of animals allowed to be killed; shooting hours; and opening and closing dates of hunting seasons. These regulations influence the harvest, which in turn influences the population status the following year.

To determine harvest goals and quotas, wildlife managers require information on the population productivity and status of wildlife stocks. This information is pieced together from a number of sources. Hunter questionnaires and compulsory registration of kills provide information about age, population and sex ratios. Among trappers, information is gathered from mandatory registration, which occurs before pelts can be sold, processed or exported. Data on the population and health of species are also gathered through the use of aerial surveys, ground surveys and interviews with conservation personnel. Inventories are conducted periodically to maintain records of population levels of the species. Evaluating the status of a diverse range of species over a vast area remains a significant challenge. Wildlife managers must make decisions using population trend and harvest data that are often imprecise.

Figure 5.4.4
Canada Goose and Mallard Duck Harvest, 1979-1997



Note:
1997 data are preliminary.
Source:
Canadian Wildlife Service Waterfowl Committee, 1998, *Status of Migratory Game Birds in Canada, November 2, 1998*, A. Filion and K.M. Dickson (eds.), Canadian Wildlife Service Unpublished Report, Ottawa.

Migratory bird management

International agreements are important in the management of migratory birds that fly freely across borders. In 1916, following a drastic decline in migratory bird populations, Canada and the United States signed the Migratory Birds Convention to regulate hunting and promote conservation. In 1986, Canada and the United States signed the more ambitious North American Waterfowl Management Plan (NAWMP), with Mexico joining in 1994. This 15-year, $1.5-billion conservation program protects and enhances wetland habitat throughout North America while promoting sustainable agricultural practices. Its goal is to restore populations of ducks, swans and geese to the levels of the 1970s.[3]

In Canada, the NAWMP is implemented in all provinces and territories, through partnerships involving federal and provincial/territorial government agencies, non-government organizations, the private sector and landowners.[4] Wildlife Habitat Canada and Ducks Unlimited are the major non-government partners.

To date, the NAWMP has been a success. More than two million acres of habitat have been conserved in North America[5] and population levels of several species of ducks have begun to increase.

1. Dilworth-Christie, P. and K.M. Dickson, 1997, *Status of Migratory Game Birds in Canada, November 3, 1997*, Canadian Wildlife Service Unpublished Report, Ottawa.
2. Environment Canada, Canadian Wildlife Service, *Focus on the Canadian Wildlife Service*. <http://www.ec.gc.ca/cws-scf/focus.html>, (accessed March 30, 1998).
3. Ducks Unlimited Canada, *North American Waterfowl Management Plan (NAWMP)*, <http://www.ducks.ca/habitat/habcons.htm>, (accessed March 16, 1998).
4. Environment Canada, *The North American Waterfowl Management Plan–Canada*, <http://www.cws-scf.ec.gc.ca/nawmp/nawmp_e.html>, (accessed August 30, 1999).
5. Ducks Unlimited Canada, *op. cit.*

5.5 Water resources

Perhaps more than any other resource, water has shaped the development of our nation. The early fur traders relied on water for long-distance transportation. Water powered the gristmills and sawmills that were the forerunners of today's manufacturing industries. As the economy diversified, water was put to new uses—initially for steam power and eventually for electric power generation. More recently, water has become valued for its properties as a coolant and solvent.

5.5.1 Water supply

Water is dynamic—at any given moment it can be found flowing under the ground and in rivers, lakes and oceans, as well as falling from the sky. This continual flow of water is known as the hydrologic cycle (Figure 5.5.1). A basic understanding of the elements of this cycle is useful when studying statistics on water supply and use.

The hydrologic cycle begins when water vapour enters the atmosphere through evaporation from surface waters and transpiration from plants. When newly moistened air rises, it cools and the water vapour recondenses to form clouds and precipitation. Once water reaches the ground again, it evaporates back into the atmosphere immediately, penetrates the surface and becomes groundwater, or runs off directly to surface waters. Groundwater eventually seeps into streams, rivers, lakes and oceans.

The interaction of climate and geography is what drives the hydrologic cycle. In Canada, warm, moist air from the West Coast is forced over the Rocky Mountains by the prevailing winds. As it crosses the mountains, it loses its moisture as precipitation and becomes fairly dry by the time it reaches the Prairies. Further east, the Great Lakes and the Atlantic Ocean increase moisture and precipitation.

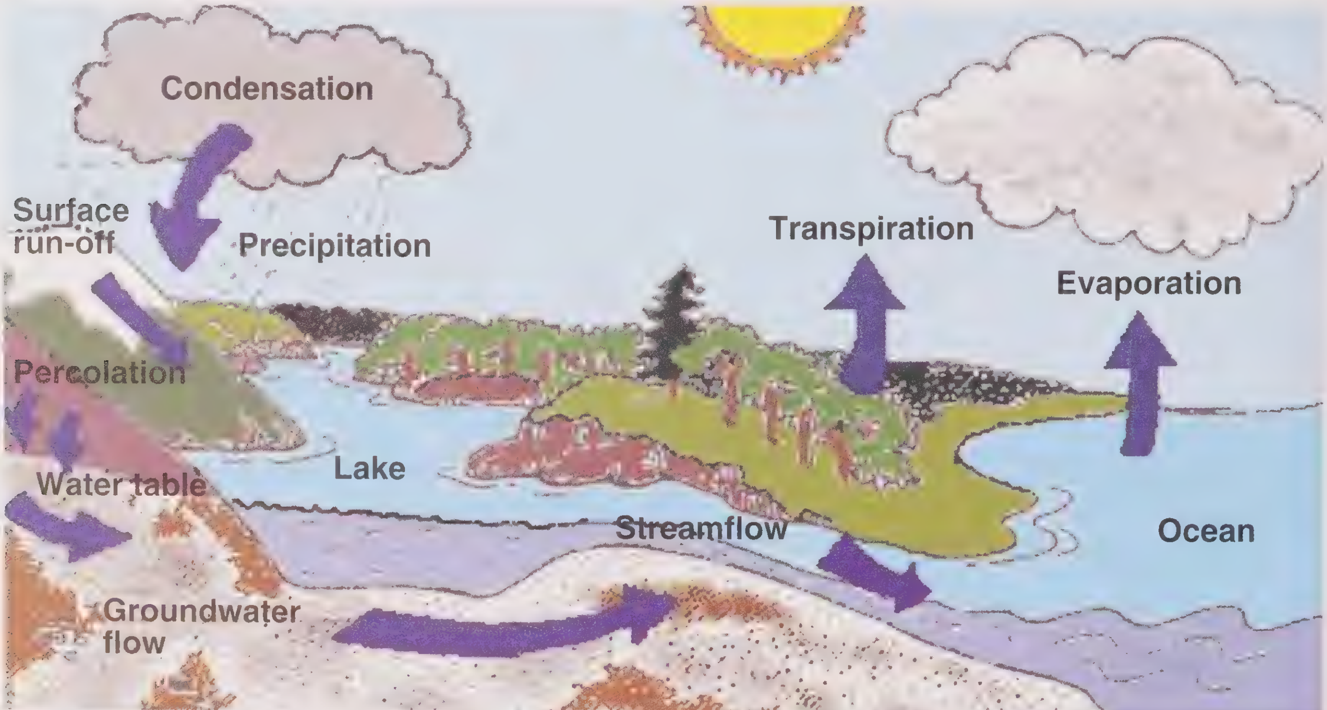
Streamflow

Canada has an abundance of renewable fresh water. The best measure of this supply is total river flow, also referred to as streamflow.

Total annual streamflow in Canada averages about 105 000 cubic metres (m^3) per second.[1] This represents some 9% of the world's renewable water supply. In contrast, Canada has less than 1% of the world's population. Rivers

1. Pearse, P. H., F. Bertrand and J. W. MacLaren, 1985, *Currents of Change: Final Report, Inquiry on Federal Water Policy*, Environment Canada, Ottawa.

Figure 5.5.1
Hydrologic Cycle



Source:
Environment Canada, 1994, *A Primer on Fresh Water*, The Environmental Citizenship Series, Ottawa. Reproduced with permission of the Minister for Public Works and Government Services.

in the United States, which support 10 times the population, discharge 8% of the global renewable water supply. The world's largest river, the Amazon, discharges about 18% of all renewable water. Average annual streamflow for large rivers in Canada is shown on Map 5.5.1. Table 5.5.1 identifies the rivers numbered on this map and indicates their average annual streamflow in m^3 per second.

Despite its abundance, fresh water is not uniformly distributed across the country. Approximately 60% of Canada's fresh water drains to the north, while 85% of the population lives along the southern border with the United States. As a result, supply does not always meet demand. Even in the Great Lakes sub-basin, the world's largest freshwater lake system, some off-lake areas experience water shortages.[1]

Streamflow by drainage basin

One-quarter of all streamflow in Canada empties into the Pacific Ocean through drainage basins[2] west of the Rocky Mountain divide. This water-rich region covers just 10% of the country and is home to the same percentage of its population. Some of Canada's largest rivers are found here, including the Fraser, Yukon and Columbia.

The immense Arctic Ocean and Hudson Bay drainage basins cover close to three-quarters of the country. They account for almost half of all streamflow but less than one-fifth of the population lives in this mostly northern area. Although precipitation is relatively light, low temperatures ensure significant streamflow by reducing evaporation and transpiration.

It is in the Great Lakes, Ottawa River and St. Lawrence River sub-basins where the greatest imbalance between population and renewable water supply is found. These sub-basins of the Atlantic Ocean drainage basin are home to over half of the population of Canada. Yet less than 7% of Canada's total streamflow originates here.

The Atlantic Ocean sub-basins east of the St. Lawrence River occupy 9% of the nation's area, contain 12% of its population and contribute nearly 20% of the country's streamflow.

The only streamflow heading toward the Gulf of Mexico from Canada originates in a tiny portion of southern Alberta and Saskatchewan.

Table 5.5.1
Average Annual Streamflow for Large Rivers by Drainage Basin

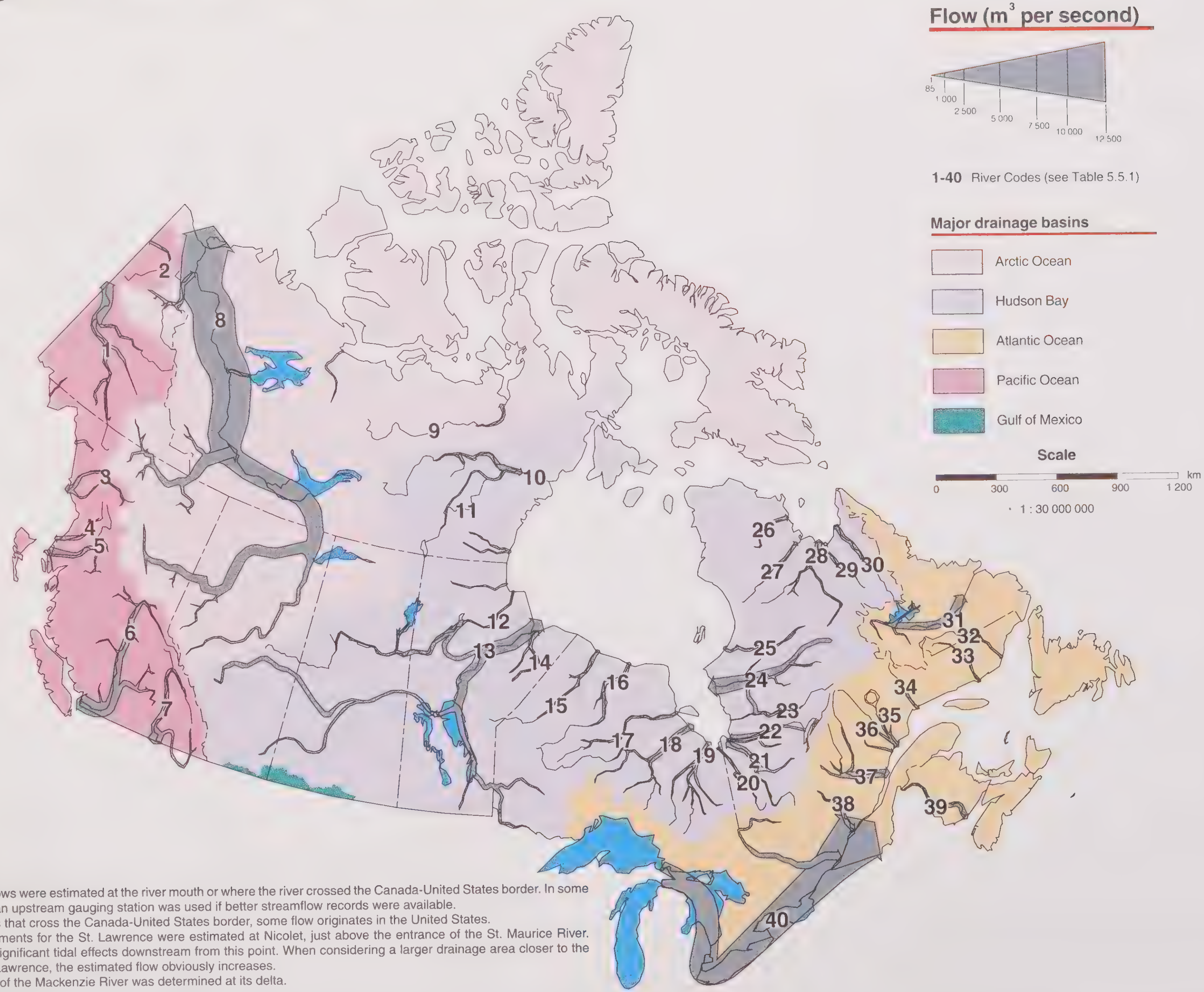
Map number	Drainage basin/ River	Average annual streamflow m^3 per second
	Pacific Ocean	24 100
1	Yukon	2 360
2	Porcupine	368
3	Stikine	1 080
4	Nass	892
5	Skeena	1 760
6	Fraser	3 620
7	Columbia	2 890
	Other rivers	11 100
	Arctic Ocean	16 400
8	Mackenzie	9 910
9	Back	612
	Other rivers	5 890
	Hudson Bay	30 900
10	Thelon	804
11	Kazan	566
12	Churchill	1 270
13	Nelson	2 830
14	Hayes	694
15	Severn	722
16	Winisk	694
17	Attawapiskat	626
18	Albany	1 420
19	Moose	1 440
20	Harricana	473
21	Nottaway	1 130
22	Rupert	878
23	Eastmain	909
24	La Grande Rivière	1 720
25	Grande Rivière de la Baleine	665
26	Arnaud	654
27	Aux Feuilles	575
28	Koksoak	2 420
29	Rivière à la Baleine	581
30	George	881
	Other rivers	8 950
	Atlantic Ocean	33 400
31	Churchill	1 620
32	Petit Mécatina	524
33	Natashquan	422
34	Moisie	490
35	Manicouagan	852
36	Aux Outardes	399
37	Saguenay	1 760
38	St. Maurice	731
39	Saint John	1 100
40	St. Lawrence	10 100
	Other rivers	15 400
	Gulf of Mexico	25
	Total	105 000

Note:
Figures may not add up to totals due to rounding.
Source:
Fisheries and Environment Canada, 1978, *Hydrological Atlas of Canada*, Catalogue No En 37-26/1978, Ottawa.

1. Environment Canada, 1994, *A Primer on Fresh Water*, The Environmental Citizenship Series, Ottawa.
2. See Map 3.1.2–**Drainage Basins** for more detail.

Map 5.5.1

Average Annual Streamflow for Major Rivers in Canada



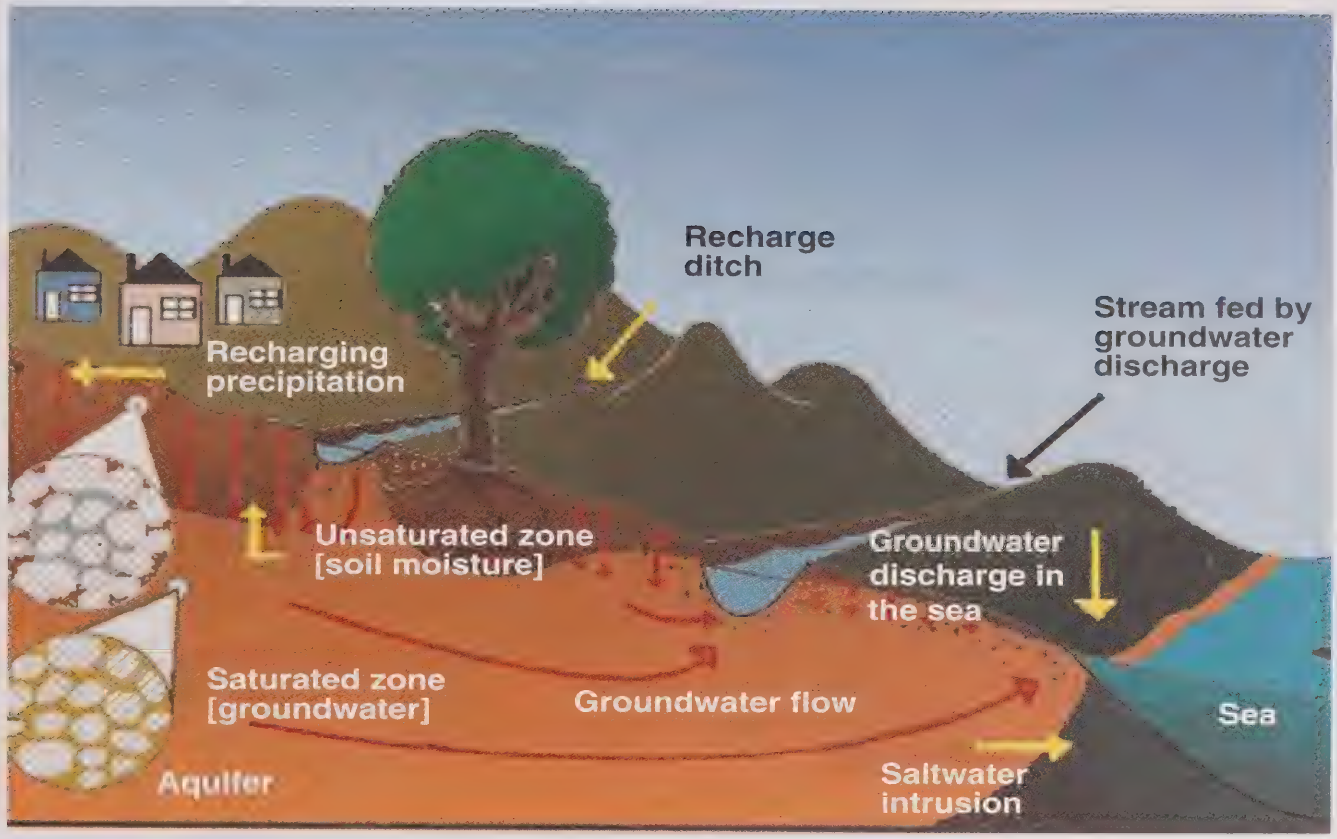
Notes:

1. Streamflows were estimated at the river mouth or where the river crossed the Canada-United States border. In some instances, an upstream gauging station was used if better streamflow records were available.
2. For rivers that cross the Canada-United States border, some flow originates in the United States.
3. Measurements for the St. Lawrence were estimated at Nicolet, just above the entrance of the St. Maurice River. There are significant tidal effects downstream from this point. When considering a larger drainage area closer to the Gulf of St. Lawrence, the estimated flow obviously increases.
4. The flow of the Mackenzie River was determined at its delta.

Source:

Fisheries and Environment Canada, 1978, *Hydrological Atlas of Canada*, Catalogue No. En 37-26/1978, Ottawa.

Figure 5.5.2
Groundwater Flow



Source:
Environment Canada, 1993, *Groundwater—Nature's Hidden Treasure*, The Environmental Citizenship Series, Ottawa. Reproduced with permission of the Minister for Public Works and Government Services.

Precipitation

Annual precipitation in Canada ranges from 100 millimetres in the high Arctic to over 3 500 millimetres along the Pacific Coast, with an average of about 600 millimetres. More than a third of this precipitation typically falls as snow. Further details on precipitation and climate are outlined in section 3.3–**Climate**. Map 3.3.4 shows average annual precipitation in Canada.

Precipitation faces several fates once it reaches the ground. A portion of it re-evaporates immediately. Another portion seeps through the surface to become groundwater. The remainder runs off directly into surface water bodies. The amount of water entering each of these pathways is a complex function of precipitation type, temperature, wind, sunshine, geology, topology, soil type and vegetative cover.[1]

Average annual run-off for Canada is illustrated on Map 5.5.2.

1. Fisheries and Environment Canada, 1978, *Hydrological Atlas of Canada*, Catalogue No. En 37-26/1978, Ottawa.

Lakes and wetlands

Lakes store water during periods of high precipitation and snowmelt and release it gradually, allowing rivers to survive through dry periods. With 8% of its territory covered by lakes, Canada has more lake area than any other country in the world. Wetlands[2] cover a further 14% and perennial snow and ice 2%.

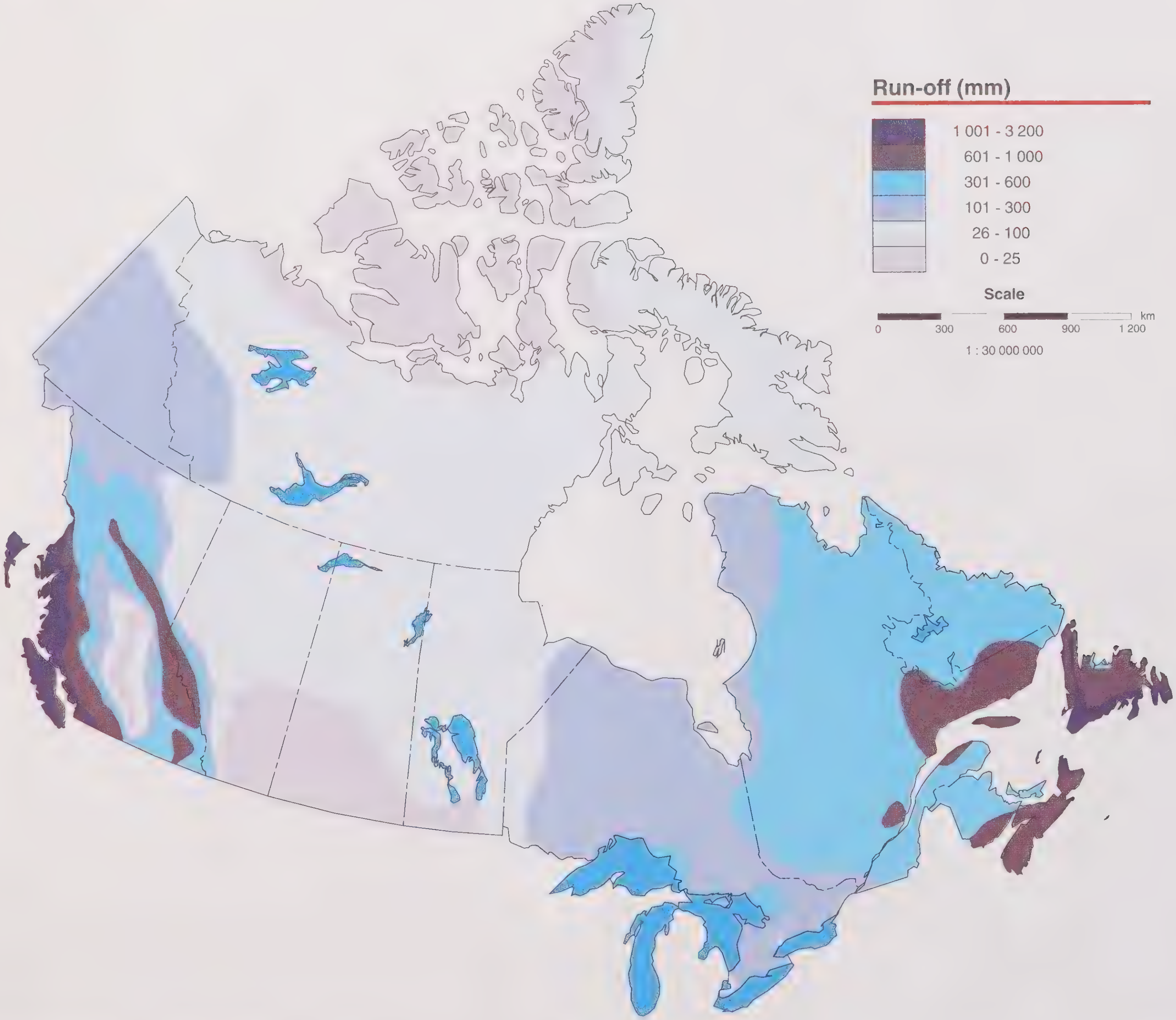
Major lakes, with a chart of area, are shown on Map 3.2.5 in section 3.2–**Physiography**. Text Box 5.5.1 presents some facts on the Great Lakes in particular.

Groundwater

Groundwater is available water found below the earth's surface. A related concept is the water table, which is the level below which groundwater is found. As illustrated in Figure 5.5.2, the area above the water table (where spaces

2. Wetlands are areas where the water table occurs above or near the land surface for at least part of the year. When open water is present, it must be less than two metres deep and stagnant or slow-moving to qualify as a wetland.

Map 5.5.2
Average Annual Run-off



Source:
Fisheries and Environment Canada, 1978, *Hydrological Atlas of Canada*, Catalogue No. En 37-26/1978, Ottawa.

Table 5.5.2
Groundwater Use in Canada, 1996

Province/Territory	Population reliant on groundwater[1]		Municipal water systems reliant on groundwater[2]	
	number	percent	number	percent
Newfoundland	189 921	33.9	19	23.5
Prince Edward Island	136 188	100.0	5	100.0
Nova Scotia	426 433	45.8	15	41.7
New Brunswick	501 075	66.5	40	72.7
Quebec	2 013 340	27.7	142	36.7
Ontario	3 166 662	28.5	132	42.7
Manitoba	342 601	30.2	22	50.0
Saskatchewan	435 941	42.8	44	65.7
Alberta	641 350	23.1	36	29.0
British Columbia	1 105 803	28.5	63	45.3
Yukon Territory	15 294	47.9	4	100.0
Northwest Territories	18 971	28.1	-	-
Canada	**8 993 579**	**30.3**	**522**	**41.2**

Notes:
1. It is assumed the population not covered by the Municipal Water Use Database is rural and that 90% of this population is groundwater reliant (except in P.E.I., where 100% of the population is known to be groundwater reliant).
2. Includes population and municipal water systems that are reliant on groundwater only, as well as those that are reliant on groundwater and surface water.
Sources:
Environment Canada, Municipal Water Use Database.
Statistics Canada, 1996, *Quarterly Estimates of the Population of Canada, the Provinces and the Territories*, Catalogue No. 91-001, Vol. 11, No. 3, Ottawa.

Text Box 5.5.1
Great Lakes Facts

- The Great Lakes and St. Lawrence River contain approximately 18% of the world's fresh surface water.
- Their shorelines account for 4% of the total length of Canada's coasts.
- Their sub-basins are home to 35% of the Canadian population.
- Lake Superior is the largest, deepest and coldest of the lakes. Water takes about 191 years to flow from one end to the other of this vast lake.
- Lake Erie is exposed to the greatest effects of urbanization and agriculture and is the shallowest, with an average depth of only 19 metres. Water flows through Lake Erie in under three years.
- Lake Ontario is 86 metres deep on average and water requires six years to flow through it.

Source:
United States Environmental Protection Agency and Government of Canada, 1995, *The Great Lakes: An Environmental Atlas and Resource Book*, Washington and Ottawa.

in the rock and soil contain both air and water) is the unsaturated zone. Water in this zone, known as soil moisture, is not readily available for human use. The region below the water table is the saturated zone.

Groundwater is sometimes found in underground formations of permeable rock or loose material called aquifers. These formations spontaneously produce water when tapped by a well.

Major aquifers in Canada[1]

Many aquifers in Canada are found in deposits of sand and gravel formed by rivers or lakes that were created from melting glaciers during the last ice age. Aquifers of this type provide most of the water supply for the Kitchener–Waterloo region in Ontario and the Fredericton area in New Brunswick. In Manitoba, the Carberry aquifer (a long-buried delta of the ice-age Lake Agassiz) is a prime source of agricultural irrigation water. A major sand and gravel aquifer located in British Columbia's Fraser Valley is widely used for municipal, domestic and industrial supply.

Beneath the soil of Prince Edward Island, water found in a thick, fractured formation of sandstone provides the Island with its entire water supply. In Winnipeg and Montréal, substantial aquifers formed from fractured rock are used for industrial water supply.

As well as these major population centres, many individual farms and rural homes depend on aquifers for their water needs.

Table 5.5.2 shows reliance of the population on groundwater in 1996.

5.5.2 Water use

Water for human activities is either used 'instream' or withdrawn from its source for use in economic or household activities. Examples of instream water use include hydroelectric power generation, transportation and recreation.

1. Environment Canada, 1994, *A Primer on Fresh Water*, The Environmental Citizenship Series, Ottawa.

Table 5.5.3
Hydro-electric Power Generation by Province and Territory, 1994-1997

Province/Territory	1994 Hydro	1994 Total electric power	1994 Hydro as share of total	1995 Hydro	1995 Total electric power	1995 Hydro as share of total	1996 Hydro	1996 Total electric power	1996 Hydro as share of total	1997 Hydro	1997 Total electric power	1997 Hydro as share of total
	gigawatt hours		percent	gigawatt hours		percent	gigawatt hours		percent	gigawatt hours		percent
Newfoundland	37 606.7	38 482.6	97.7	36 287.0	37 910.5	95.7	35 292.1	36 773.3	96.0	40 177.0	41 747.7	96.2
Prince Edward Island	-	40.0	-	-	21.8	-	-	8.8	-	-	20.9	-
Nova Scotia	1 020.4	9 767.4	10.4	904.4	9 571.1	9.4	1 123.7	10 175.4	11.0	978.3	10 517.8	9.3
New Brunswick	2 772.2	15 891.2	17.4	2 706.1	12 786.8	21.2	3 531.5	15 483.0	22.8	2 373.0	16 779.5	14.1
Quebec	157 850.7	163 600.7	96.5	167 945.3	173 097.6	97.0	165 201.2	171 275.6	96.5	160 831.7	166 218.8	96.8
Ontario	39 080.7	152 429.2	25.6	38 808.9	151 747.1	25.6	41 659.2	148 211.0	28.1	39 966.1	147 065.3	27.2
Manitoba	28 146.2	28 443.4	99.0	29 013.3	29 238.1	99.2	30 865.7	31 183.5	99.0	33 391.3	33 660.7	99.2
Saskatchewan	3 392.5	15 478.1	21.9	4 118.4	16 395.9	25.1	4 375.9	16 555.0	26.4	3 986.5	16 879.6	23.6
Alberta	1 806.3	52 361.3	3.4	2 190.2	52 452.7	4.2	2 260.6	52 006.6	4.3	2 170.4	54 069.2	4.0
British Columbia	54 304.1	62 070.4	87.5	50 181.3	59 053.8	85.0	67 668.3	72 673.5	93.1	63 319.8	68 750.1	92.1
Yukon Territory	266.1	299.3	88.9	314.4	386.6	81.3	360.9	500.0	72.2	257.4	374.7	68.7
Northwest Territories	188.2	578.1	32.6	204.4	808.7	25.3	264.1	835.3	31.6	292.4	802.6	36.4
Canada	**326 434.1**	**539 441.7**	**60.5**	**332 673.6**	**543 470.5**	**61.2**	**352 603.2**	**555 680.9**	**63.5**	**347 743.9**	**556 886.9**	**62.4**

Note:
Figures may not add up to totals due to rounding.
Sources:
Statistics Canada, *Electric Power Annual Statistics*, Catalogue No. 57-202, Ottawa.
Statistics Canada, *Quarterly Report on Energy Supply-Demand in Canada*, Catalogue No. 57-003, Ottawa.

When water is withdrawn from its source for use, some or all of it is eventually returned to the original source, often with just a short delay. The quantity of water originally withdrawn is referred to as 'intake' and that returned to the source as 'discharge.' The difference between intake and discharge (the amount actually used up in the process) represents 'consumption.'[1]

Main instream uses of water

Hydro-electric power generation

Table 5.5.3 shows that Canada depends very much on hydro-electric power generation; overall, 62% of our electricity needs were met by hydro-electricity in 1997. Three provinces—Newfoundland, Quebec and Manitoba—produced virtually all their electricity in this manner. In contrast, the second largest electricity producer, Ontario, used water to meet only 27% of its electricity generation needs. The majority of Ontario's electricity was produced by nuclear power.

See section 5.6–**Energy resources** for more details on energy production and consumption.

Water transport

Water is the most economical means of moving Canada's bulky commodity exports: wheat, pulp, lumber, fossil fuels and minerals.[2] The main transportation waterways are the St. Lawrence Seaway–Great Lakes Waterway, which allows passage of ocean-going ships from the Atlantic Ocean into the North American heartland (Text Box 5.5.2); the Mackenzie River, which is a vital northern transportation link; and the lower Fraser River on the Pacific Coast.

Table 5.5.4 shows the tonnage of the top three commodities loaded and unloaded at some of Canada's leading ports in 1997.

Fishing

The 1996 commercial freshwater fishery harvested 58 000 tonnes of fish, valued at $64 million. The principal species targeted were lake whitefish, yellow pickerel and perch. Production of farmed trout added a further 57 000 tonnes, valued at approximately $29 million.[3]

Canada's waters are also home to some of the best sport fishing in the world. Over 4.2 million Canadian and visiting anglers took advantage of this fact in 1995, spending $7.4 billion in the process.[4]

For more details on Canada's fisheries, see sections 4.5–**Fisheries** and 5.3–**Marine resources**.

Main withdrawal uses of water

Table 5.5.5 shows statistics for major withdrawal uses of water in 1981, 1986 and 1991.

1. Water is never really 'used up.' Even though it may be transported far from its original source or changed from liquid to gas, all water eventually makes its way back into the hydrologic cycle.
2. Environment Canada, 1993, *Water Works!* The Environmental Citizenship Series, Ottawa.
3. Department of Fisheries and Oceans, Statistical Services, <www.dfo-mpo.gc.ca>, (accessed June 24, 1999).
4. Department of Fisheries and Oceans, 1996, *Highlights of the 1995 Survey of Recreational Fishing in Canada*, Ottawa.

Table 5.5.4
Activity at Selected Ports, 1997

Port	Domestic cargo			International cargo			Total cargo		
	Loaded	Unloaded	Total	Loaded	Unloaded	Total	Loaded	Unloaded	Total
	thousand tonnes								
Vancouver - Total	**648**	**351**	**999**	**65 192**	**5 607**	**70 799**	**65 840**	**5 958**	**71 798**
Coal	-	-	-	28 294	-	28 294	28 294	-	28 294
Wheat	-	-	-	8 341	-	8 341	8 341	-	8 341
Sulphur	8	-	8	5 499	-	5 499	5 507	-	5 507
Sept-Iles/Pointe-Noire - Total	**2 473**	**1 073**	**3 546**	**20 060**	**865**	**20 925**	**22 533**	**1 938**	**24 471**
Iron ore	2 421	-	2 421	19 727	-	19 727	22 148	-	22 148
Aluminum ore and basic products	-	-	-	173	354	527	173	354	527
Other non-metallic mineral products	27	168	195	1	167	168	28	335	363
Montréal/Contrecoeur - Total	**1 203**	**4 403**	**5 606**	**6 505**	**8 498**	**15 003**	**7 708**	**12 901**	**20 609**
Machinery, equipment and miscellaneous cargo	322	11	333	1 127	1 536	2 663	1 449	1 547	2 996
Wheat	-	1 656	1 656	1 122	-	1 122	1 122	1 656	2 778
Miscellaneous chemicals	4	40	44	1 103	1 303	2 406	1 107	1 343	2 450
Halifax - Total	**1 787**	**801**	**2 588**	**5 649**	**6 576**	**12 225**	**7 436**	**7 377**	**14 813**
Crude petroleum	-	-	-	1	4 043	4 044	1	4 043	4 044
Gypsum	396	-	396	2 944	-	2 944	3 340	-	3 340
Machinery, equipment and miscellaneous cargo	176	78	254	689	1 159	1 848	865	1 237	2 102
Port Cartier - Total	**3 139**	**2 225**	**5 364**	**14 205**	**1 333**	**15 538**	**17 344**	**3 558**	**20 902**
Iron ore	3 136	-	3 136	11 997	-	11 997	15 133	-	15 133
Wheat	-	1 619	1 619	1 482	92	1 574	1 482	1 711	3 193
Fodder and feed (includes soya beans)	3	-	3	453	762	1 215	456	762	1 218
Thunder Bay - Total	**8 018**	**324**	**8 342**	**4 271**	**236**	**4 507**	**12 289**	**560**	**12 849**
Wheat	7 014	-	7 014	1 077	-	1 077	8 091	-	8 091
Coal	459	-	459	637	187	824	1 096	187	1 283
Potassium chloride	54	-	54	641	-	641	695	-	695

Source:
Statistics Canada, 1999, *Shipping in Canada 1997*, Catalogue No. 54-205, Ottawa.

Text Box 5.5.2
The St. Lawrence Seaway–Great Lakes Waterway

The St. Lawrence Seaway–Great Lakes Waterway was built jointly by Canada and the United States between 1954 and 1959. It consists of the open waters of the Great Lakes and the St. Lawrence River together with all the linking canals, locks, dams, control structures and harbours. Totalling 3 790 kilometres, it is the world's longest inland shipping lane.

The economic impact of the Seaway system on the Canadian economy is estimated at between $2 billion and $4 billion annually, with the movement of more than 200 million tonnes of cargo.[1]

A new challenge appeared during the 1998 shipping season: unusually low rainfall and warm temperatures led to historically low water levels, particularly at the Port of Montréal. Ship operators were forced to lighten their cargo holds or completely bypass Montréal. Losses of more than US$1.2 million a week were incurred by the shipping industry.[2]

1. Environment Canada, 1996, *The State of Canada's Environment 1996*, Ottawa.
2. MacGregor, Alison, 1998, "Low Water Levels Sink Shipping Trade," *The Ottawa Citizen*, December 18, p. H4.

Thermal power generation

This industry, which includes both fossil fuel and nuclear power generating stations, was responsible for 63% of total water intake in 1991. Production of one kilowatt-hour of electricity, about enough to light a small house for an hour, requires 140 litres of water in a typical fossil fuel generating plant and 205 litres in a typical nuclear generating station.[1] Most of this water is used for cooling purposes and is returned to its source, at an elevated temperature, soon after use.

Manufacturing

Water is used as a raw material, a coolant, a solvent and a material transport medium in manufacturing. In 1991, the manufacturing industries together accounted for 16.5% of water withdrawals in the economy. The individual industries using the most water were Paper and Allied Products (6.5% of total withdrawals), Primary Metal (3.6%) and Chemical and Chemical Products (2.9%).

Municipal use

Water use in towns and cities for tap water, fire hydrants, street cleaning, parks and recreation centres, and commercial businesses accounted for about 10% of total water withdrawals in 1991.

1. Environment Canada, 1993, *Water Works!* The Environmental Citizenship Series, Ottawa.

Table 5.5.5
Major Withdrawal Uses of Water, 1981, 1986 and 1991

Industry/Sector	Year	Total intake: Quantity	Total intake: Change from previous period	Recirculation: Quantity	Recirculation: Change from previous period	Gross water use: Quantity	Gross water use: Change from previous period	Total discharge: Quantity	Total discharge: Change from previous period	Consumption: Quantity	Consumption: Change from previous period
		million m^3	percent	million m^3	percent	million m^3	percent	million m^3	percent	million m^3	percent
Business sector											
Agriculture	1981	3 125	...	-	...	3 125	...	713	...	2 412	...
	1986	3 559	13.9	-	...	3 559	13.9	807	13.2	2 752	14.1
	1991	3 991	12.1	-	...	3 991	12.1	902	11.8	3 089	12.2
Mining	1981	624	...	1 742	...	2 366	...	621	...	3	...
	1986	544	-12.8	1 159	-33.5	1 703	-28.0	542	-12.7	2	-39.4
	1991	489	-10.1	1 221	5.3	1 710	0.4	489	-9.8	1	-44.4
Other primary resource industries	1981	252	...	1 050	...	1 302	...	189	...	63	...
	1986	180	-28.6	873	-16.9	1 054	-19.0	118	-37.6	62	-1.6
	1991	183	1.7	735	-15.8	918	-12.9	111	-5.9	71	14.5
Paper and Allied Products	1981	3 170	...	4 612	...	7 782	...	2 989	...	181	...
	1986	3 082	-2.8	3 121	-32.3	6 203	-20.3	2 876	-3.8	206	13.8
	1991	2 943	-4.5	2 206	-29.3	5 149	-17.0	2 758	-4.1	185	-10.2
Primary Metal	1981	2 074	...	1 325	...	3 399	...	2 003	...	71	...
	1986	2 057	-0.8	1 945	46.8	4 002	17.7	2 014	0.5	43	-39.4
	1991	1 610	-21.7	1 689	-13.2	3 298	-17.6	1 518	-24.6	92	114.0
Chemical and Chemical Products	1981	3 188	...	1 285	...	4 473	...	2 963	...	225	...
	1986	1 694	-46.9	1 494	16.3	3 189	-28.7	1 630	-45.0	64	-71.6
	1991	1 326	-21.7	979	-34.5	2 305	-27.7	1 231	-24.5	95	48.4
Other manufacturing industries	1981	1 721	...	2 287	...	4 007	...	1 588	...	133	...
	1986	1 548	-10.1	1 880	-17.8	3 427	-14.5	1 422	-10.5	126	-5.3
	1991	1 570	1.4	1 860	-1.1	3 430	0.1	1 394	-2.0	175	38.9
Electric power and other utilities	1981	18 166	...	1 868	...	20 034	...	18 084	...	82	...
	1986	24 964	37.4	3 776	102.1	28 740	43.5	24 703	36.6	261	218.3
	1991	28 289	13.3	3 374	-10.6	31 664	10.2	28 184	14.1	105	-59.8
Other industries	1981	638	...	-	...	638	...	575	...	63	...
	1986	735	15.2	-	...	735	15.2	659	14.6	76	20.6
	1991	816	11.0	-	...	816	11.0	731	10.9	86	13.2
Subtotal, business sector	**1981**	**32 958**	**...**	**14 169**	**...**	**47 126**	**...**	**29 725**	**...**	**3 233**	**...**
	1986	**38 363**	**16.4**	**14 248**	**0.6**	**52 612**	**11.6**	**34 771**	**17.0**	**3 592**	**11.1**
	1991	**41 217**	**7.4**	**12 064**	**-15.3**	**53 281**	**1.3**	**37 317**	**7.3**	**3 899**	**8.5**
Personal and government sectors	1981	3 760	...	-	...	3 760	...	3 363	...	397	...
	1986	3 719	-1.1	-	...	3 719	-1.1	3 338	-0.7	381	-4.0
	1991	3 802	2.2	-	...	3 802	2.2	3 374	1.1	428	12.4
Total, whole economy	**1981**	**36 717**	**...**	**14 169**	**...**	**50 886**	**...**	**33 087**	**...**	**3 629**	**...**
	1986	**42 083**	**14.6**	**14 248**	**0.6**	**56 330**	**10.7**	**38 109**	**15.2**	**3 973**	**9.5**
	1991	**45 019**	**7.0**	**12 064**	**-15.3**	**57 083**	**1.3**	**40 691**	**6.8**	**4 327**	**8.9**

Note:
Figures may not add up to totals due to rounding.
Source:
Statistics Canada, Environment Accounts and Statistics Division.

Agriculture

Agriculture accounted for 9% of total 1991 withdrawals. This water was used mainly for irrigation (85%), but also for livestock watering (15%). Because of the high rate of evaporation from agricultural fields, irrigation is a highly consumptive use (that is, very little of the water withdrawn for irrigation is returned to its source).

5.5.3 Management of water resources

Legislative arrangements

Under the Canadian Constitution, responsibility for natural resources, including water, rests mainly with provincial governments. Some examples of provincial water legislation include Manitoba's *Clean Environment Act*, Ontario's *Water Resources Act* and Newfoundland's *Water Protection Act*. In many cases, municipalities share responsibility for water management, particularly for municipal water supply and wastewater treatment.

Table 5.5.6
Interbasin Water Diversions by Province

Province/Territory	Diversions	Average annual flow	Major use
	number	m^3 per second	
Newfoundland	5	725	hydro
Prince Edward Island	-	-	-
Nova Scotia	4	18	hydro
New Brunswick	2	2	municipal
Quebec	6	1 854[1]	hydro
Ontario	9	564	hydro
Manitoba	5	779[2]	hydro
Saskatchewan	5	30	hydro
Alberta	9	117	irrigation
British Columbia	9	361	hydro
Yukon Territory	-	-	-
Northwest Territories	-	-	-
Canada	**54**	**4 450**	**hydro**

Notes:
1. Excludes Beauharnois Canal flows from the St. Lawrence River.
2. Excludes floodway flows of short duration (Portage Diversion, Winnipeg Floodway, Seine Diversion).
Source:
F. Quinn, Environment Canada, personal communication.

Table 5.5.7
Large Dams[1] by Province and Territory

Province/Territory	Number of dams
Newfoundland	86
Prince Edward Island	-
Nova Scotia	35
New Brunswick	16
Quebec	203
Ontario	81
Manitoba	34
Saskatchewan	43
Alberta	57
British Columbia	89
Yukon Territory	3
Northwest Territories	3
Canada	**650**

Note:
1. Large dams are defined by the International Commission on Large Dams as any dams higher than 15 metres, as well as dams between 10 and 15 metres in height, provided one of the following conditions is met: a) length of crest is greater than 500 metres; b) reservoir capacity is greater than 1 million m^3; c) maximum discharge is greater than 2 000 m^3 per second.
Source:
F. Quinn, Environment Canada, personal communication.

The federal government has responsibility for navigable waters and commercial fisheries, as well as for national and international boundary waters and those on First Nations' lands and in the northern territories.

With respect to international boundary waters, the oldest and most important agreement between Canada and the United States is the Boundary Waters Treaty of 1909. Basic principles for the use, obstruction and diversion of boundary and transboundary waters are established by the treaty and administered by the International Joint Commission.

Other federal legislation involving management of water includes *The Fisheries Act*, *The Canadian Environmental Protection Act*, *The Canada Shipping Act* and *The Northern Inland Waters Act*. For projects that involve joint federal–provincial management of water resources, *The Canada Water Act* provides the framework.

Dams and diversions

Many countries divert water from where it is plentiful to where it is scarce. Diversions consolidate water from two or more sources, usually rivers, into one trunk line to increase the security and quantity of flow. They may be put in place to support hydro-electric power generation, to increase water supplies in dry regions or to deflect watercourses away from flood-prone areas.

More water is diverted in Canada than in any other country in the world.[1] Most of the nation's diversions exist to support hydro-electric power development (Table 5.5.6).

Dams often go hand in hand with diversions. Water is retained in its drainage basin of origin by a dam and diverted to adjoining basins through natural channels, pipelines, canals or other means. Table 5.5.7 shows the number of large dams in Canada by province and territory.

Flood control

Flooding, a natural occurrence, is often essential to the functioning of aquatic ecosystems. However, the human hardship and economic loss it causes can be devastating.

The 1996 Saguenay River flood in Quebec led to 10 deaths and over $800 million in damages. The 1997 Red River flood in Manitoba caused damages estimated at approximately $300 million. The cost might have been several billion dollars had it not been for the presence of the Red River Floodway around Winnipeg, as well as diversions at Portage la Prairie and Ste. Rose du Lac.[2]

The National Flood Damage Reduction Program, introduced in 1976, is intended to co-ordinate federal and provincial strategies by clearly defining flood-risk areas, by discouraging investment and building in those areas, and by following up with appropriate measures to limit damage to existing development.

The program has identified urban flood-risk areas across Canada through a federal–provincial program of flood-risk mapping. It has been very successful in redirecting damage-prone development away from these areas.

1. Environment Canada, 1994, *A Primer on Fresh Water*, The Environmental Citizenship Series, Ottawa.

2. Environment Canada and Department of Foreign Affairs and International Trade, 1998, *Canada and Freshwater—Experiences and Practices*, Monograph No. 6, Sustainable Development in Canada Monograph Series, Ottawa.

Table 5.5.8
Status of the National Flood Damage Reduction Program, 1995

Province/Territory[1]	Listed in agreement	Mapping completed	Designated[2]	Zoning in place[3]
	number of flood risk areas/communities			
Newfoundland	53	19	16	11
Nova Scotia	6	6	5	5
New Brunswick	15	12	7 + (5)	-
Quebec	510	211	196 + (15)	211
Ontario	445	318	195 + (5)	200
Manitoba	26	18	14 + (3)	2
Saskatchewan	24	22	7 + (4)	1
Alberta	67	20	11	11
British Columbia	143	77	52 + (21)	50
Northwest Territories	9	9	9	2

Notes:
1. Flood damage reduction agreements were signed between the federal government and all provinces and territories except Prince Edward Island and the Yukon Territory.
2. Refers to the number of flood-risk areas in which all government investment is restricted. The numbers in parentheses indicate interim designated areas.
3. The areas mapped and designated, and for which zoning is in place to restrict private and non-government-assisted development.
Source:
Watt, Edgar W., 1995, "The National Flood Damage Reduction Program: 1976-1995," *Canadian Water Resources Journal*, Vol. 20, No. 4.

Table 5.5.8 shows the status of the flood-risk areas identified through the program as of 1995.

Conservation

Three categories of water conservation measures can be defined: physical, economic and social.

Physical measures involve changes in water-using equipment or processes to improve their efficiency. Household examples include the use of low-flow showerheads and water-conserving toilets. In 1994, 42% of households reported using low-flow showerheads and 15% reported using water-conserving toilets.[1]

Economic measures address the costs that users pay for water. Examples include recovering the full cost of water supply through municipal water rates and installing water meters so that consumers are charged according to the volume they consume. Nearly two-fifths of municipalities currently charge flat rates for water, providing no conservation incentive.[2]

Social measures cover non-economic regulatory and information initiatives. These include, for example, revisions to plumbing codes, restrictions on lawn watering, and public awareness campaigns.

In 1993, Ontario became the first province to introduce plumbing codes that require all toilets, showerheads and faucets in new buildings to be water-conserving. British Columbia introduced similar regulations for showers and faucets in 1995.[3]

1. Statistics Canada, 1995, *Households and the Environment 1994*, Catalogue No. 11-526, Ottawa.
2. Environment Canada, 1998, *Urban Water: Municipal Water Use and Wastewater Treatment*, SOE Bulletin No. 98-4, Ottawa.

3. *Ibid.*

5.6 Energy resources

Energy has always played a fundamental role in the economy. The growth in economic activity during the industrial revolution would not have been possible without the injection of vast quantities of energy. Not only the quantity of energy consumed changed dramatically following industrialization; so too did the sources of energy. While pre-industrial economies relied mainly on renewable energy sources (animal and human labour, wood, whale oil, wind and water), industrialized economies produce most of their energy from non-renewable sources (coal, crude oil, natural gas and uranium).

Table 5.6.1
Basic Energy Indicators, 1958-1997

Year	Consumption of primary energy[1]	Population	Real GDP	Energy consumption per person	Energy consumption per dollar of real GDP
	petajoules	thousands	million 1992 dollars	gigajoules	megajoules per 1992 dollar
1958	2 852.5	17 120	..	166.6	..
1959	3 037.5	17 522	..	173.4	..
1960	3 133.7	17 909	..	175.0	..
1961	3 294.0	18 271	220 816	180.3	14.92
1962	3 491.3	18 614	235 900	187.6	14.80
1963	3 740.3	18 964	247 944	197.2	15.09
1964	3 926.4	19 325	264 174	203.2	14.86
1965	4 131.3	19 678	281 249	209.9	14.69
1966	4 407.9	20 048	299 689	219.9	14.71
1967	4 524.2	20 412	308 639	221.6	14.66
1968	4 877.9	20 729	325 147	235.3	15.00
1969	5 141.3	21 028	342 468	244.5	15.01
1970	5 545.5	21 324	351 434	260.1	15.78
1971	5 889.7	21 962	370 859	268.2	15.88
1972	6 411.2	22 220	390 702	288.5	16.41
1973	6 937.4	22 494	418 797	308.4	16.57
1974	7 208.9	22 808	436 151	316.1	16.53
1975	7 080.7	23 142	445 813	306.0	15.88
1976	7 183.0	23 450	470 291	306.3	15.27
1977	7 295.6	23 726	486 562	307.5	14.99
1978	7 641.3	23 964	506 413	318.9	15.09
1979	8 176.0	24 202	527 703	337.8	15.49
1980	8 214.9	24 516	535 007	335.1	15.35
1981	7 862.6	24 820	551 305	316.8	14.26
1982	7 381.5	25 117	535 113	293.9	13.79
1983	7 299.9	25 367	549 843	287.8	13.28
1984	7 737.5	25 608	581 038	302.2	13.32
1985	7 908.8	25 843	612 416	306.0	12.91
1986	7 834.4	26 101	628 575	300.2	12.46
1987	8 122.2	26 450	654 360	307.1	12.41
1988	8 660.1	26 798	686 176	323.2	12.62
1989	8 945.2	27 286	703 577	327.8	12.71
1990	8 779.2	27 701	705 464	316.9	12.44
1991	8 632.8	28 031	692 247	308.0	12.47
1992	8 760.3	28 377	698 544	308.7	12.54
1993	9 047.5	28 703	714 583	315.2	12.66
1994	9 360.0	29 036	748 350	322.4	12.51
1995	9 522.6	29 354	767 913	324.4	12.40
1996	9 945.1	29 672	777 167	335.2	12.80
1997	10 014.5	30 004	806 737	333.8	12.41

Note:
1. Includes the use of energy resources for non-energy purposes (petrochemical feedstocks in fertilizer production, for example). Excludes the use of wood and wastes as energy sources.
Source:
Statistics Canada, Environment Accounts and Statistics Division.

Basic energy indicators

The production and distribution of energy is an important economic activity. In 1997, the industries involved[1] in these activities generated 6.5% of Gross Domestic Product (GDP) and 15.1% of total investment. At the same time, they employed 150 000 workers.[2]

With the exception of brief periods during the recessions of 1982 and 1991, total consumption of energy has been increasing since 1958 (Table 5.6.1). Annual average growth in consumption between that year and 1997 was 3.3%. Per capita consumption of energy followed the same trend, rising continuously except during the 1982 and 1991 recessions. In contrast, energy consumption per dollar of inflation-adjusted (real) GDP—a measure of the energy intensity of the economy—actually began to fall following the 1974 oil crisis. This decline suggests that the four-fold increase in crude oil prices that resulted from the oil crisis (Figure 5.6.4) provided real incentives to conserve energy. A second oil price hike in 1979 led to further reductions in energy consumption per dollar of real GDP. Oil prices dropped dramatically in 1986, after which energy consumption per dollar of real GDP stabilized at around 12.5 megajoules.

5.6.1 Stocks of energy resources

When considering stocks of energy resources, three measures are of interest: established reserves, reserve life and total resource base.

- *Established reserves* are defined as all energy deposits (oil and gas wells, coal seams, etc.) that can be profitably exploited under current economic and technological conditions and that are known to exist with a high degree of confidence. Established reserves fluctuate from year to year as existing deposits are depleted and new deposits are added (or previously non-economic deposits are re-classified as a result of changing technological and economic conditions). A constant reserve size means that current rates of depletion are exactly offset by new additions and re-classifications.
- *Reserve life* is the ratio of reserve size to current annual extraction. It provides a measure of the number of years that reserves will last at current rates of extraction.
- *Total energy resource base* provides an estimate of the energy resources that may ultimately be available

1. The following industries are involved in energy production: Coal Mines; Crude Petroleum and Natural Gas; Pipeline Transport; Refined Petroleum and Coal Products; Electric Power Systems; and Gas Distribution Systems.
2. Statistics Canada, Industry Measures and Analysis Division, Investment and Capital Stock Division, and Labour Division.

Table 5.6.2
Energy Resource Reserves, 1976-1996

	Coal[1]		Crude oil		Crude bitumen		Natural gas[2]		Uranium	
Year	Reserves	Reserve life	Reserves	Reserve life	Reserves	Reserve life	Reserves	Reserve life	Reserves	Reserve life
	megatonnes	years	million m^3	years	million m^3	years	billion m^3	years	kilotonnes	years
1976	4 310.7	169.1	1 014.6	13.9	150.7	39.7	1 738.7	26.5	405.0	74.5
1977	4 117.0	143.7	969.1	13.3	111.2	32.7	1 790.8	24.9	415.0	71.7
1978	4 092.6	134.3	942.7	13.0	321.5	68.4	1 911.8	25.1	438.0	53.3
1979	4 021.8	121.1	903.3	11.2	353.1	47.7	1 977.6	24.1	468.0	71.7
1980	4 192.5	114.4	860.7	11.4	333.9	32.4	2 028.9	27.9	444.0	65.9
1981	4 159.9	103.9	827.8	12.4	325.0	36.5	2 085.4	27.0	340.0	45.3
1982	5 704.0	133.3	780.6	12.1	315.6	33.6	2 148.3	31.1	376.0	49.2
1983	5 981.0	133.4	792.4	11.7	310.4	17.9	2 126.5	28.7	333.0	48.8
1984	6 120.6	106.7	776.3	10.6	328.8	28.3	2 106.8	27.4	260.0	25.3
1985	6 011.8	99.9	790.5	11.2	343.4	22.3	2 080.4	24.9	263.0	25.2
1986	6 338.9	109.3	774.6	11.4	574.4	30.4	2 032.7	25.7	265.0	23.0
1987	6 583.5	107.6	753.6	10.9	572.5	28.5	1 956.0	24.6	258.0	19.0
1988	6 542.3	92.5	739.2	10.2	566.5	26.5	1 931.9	19.0	248.0	20.6
1989	6 472.6	91.8	707.8	10.3	542.2	23.4	1 957.8	19.0	249.0	22.6
1990	6 580.7	95.7	657.3	9.6	524.0	23.1	1 979.2	18.0	295.0	30.3
1991	6 545.2	91.9	614.9	9.2	501.7	22.2	1 965.8	19.9	305.0	37.4
1992	6 522.1	99.3	590.4	8.5	482.2	20.3	1 929.7	15.3	309.0	33.9
1993	6 449.4	93.7	582.2	8.1	457.6	18.6	1 860.5	13.1	313.0	36.0
1994	6 372.2	87.6	544.5	7.1	565.0	23.5	1 833.3	12.7	300.0	26.8
1995	6 293.4	84.1	553.7	7.2	574.0	20.4	1 841.5	12.2	484.0	47.3
1996	6 196.9	68.3	527.2	6.7	660.8	23.5	1 726.4	11.7	430.0	37.9

Notes:
1. Includes bituminous, sub-bituminous and lignite coal.
2. Includes natural gas liquids (ethane, butane, propane and pentanes plus).
Source:
Statistics Canada, Environment Accounts and Statistics Division.

in the future, regardless of current prices, technology and knowledge. These estimates are subject to a large degree of uncertainty.

Reserve size and life

Established crude oil reserves declined by almost one-half between 1976 and 1996. This drop was mainly attributable to a declining rate of additions to reserves rather than to an increasing rate of extraction. As a result of the decline, crude oil reserve life fell from about 14 years in 1976 to about 7 years in 1996 (Table 5.6.2).

In contrast to crude oil, established reserves of both natural gas and crude bitumen (tar sands) increased from 1976 to 1996. This was particularly the case for crude bitumen reserves, which increased in size almost four-fold. Despite this increase, reserve life for crude bitumen declined, reflecting rapid growth in extraction rates. Natural gas reserve life declined as well, again reflecting increased rates of extraction.

Established reserves of uranium decreased substantially between 1976 and 1989, but increased thereafter. Reserve life followed the same trend.

Established coal reserves increased more than 40% over the period. Reserve life fell substantially, but remained high at about 68 years in 1996.

Total resource base

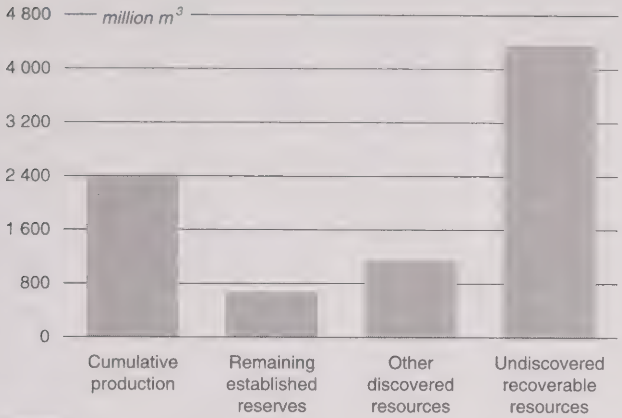
The total energy resource base is divided into two components: discovered resources and undiscovered resources. Discovered resources are those that have been shown to exist by drilling, testing or production. Undiscovered resources are stocks believed to exist based on geological and geophysical evidence.

Discovered resources are further classified into three subgroups: cumulative production, established reserves, and other discovered resources. Cumulative production is that portion of the resource base that has been produced since the beginning of extraction in Canada. Remaining established reserves were discussed above. Other discovered resources are those that, although known to exist, are not presently economically viable. Their viability requires either an increase in selling prices, or a reduction in costs as a result of technological change or the construction of new infrastructure.

The estimated total crude oil resource base in 1992[1] was 8.6 billion m^3. Of this, cumulative production had consumed 2.4 billion m^3, while remaining established reserves represented another 700 million m^3. Other discovered resources represented a further 1.1 billion m^3. Undiscovered resources were thought to be on the order of 4.4 billion m^3,

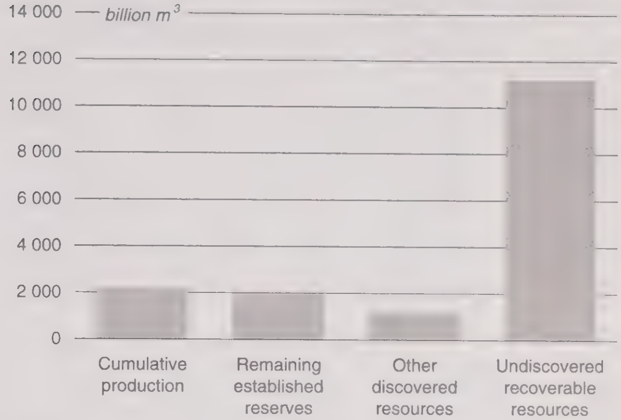
1. Estimates of total resource base are revised only periodically by the responsible agencies. At the moment, figures for 1992 are the most recent available.

Figure 5.6.1
Crude Oil Resource Base, 1992



Source:
National Energy Board, 1994, *Canadian Energy: Supply and Demand 1993-2010, Technical Report*, Catalogue No. NE23-15/3-1994E, Calgary.

Figure 5.6.2
Natural Gas Resource Base, 1992



Source:
National Energy Board, 1994, *Canadian Energy: Supply and Demand 1993-2010, Technical Report*, Catalogue No. NE23-15/3-1994E, Calgary.

of which 3.6 billion m^3 were believed to be situated in frontier (undeveloped) areas (Figure 5.6.1).

The estimated total natural gas resource base in 1992 was 16.4 trillion m^3. Of this, cumulative production had consumed 2.2 trillion m^3 and remaining established reserves represented another 1.9 trillion m^3. Other discovered resources, located in frontier basins such as the Beaufort Sea and the Grand Banks, made up 1.2 trillion m^3. Undiscovered resources were estimated to be 11.2 trillion m^3, of which 3.1 trillion m^3 were thought to remain in western Canada and 8.1 trillion m^3 in frontier basins (Figure 5.6.2).

The estimated total crude bitumen resource base in 1992 was a substantial 49 billion m^3. Cumulative production had used just 300 million m^3 (less than 1%). Remaining established reserves represented another 500 million m^3; other discovered resources made up the rest of the estimated total resource base. No estimate was made for undiscovered resources as they are expected to be insignificant relative to the size of the discovered resource.[1]

It is clear that the remaining crude oil resource base in Canada is overshadowed by the crude bitumen resource base. Given this, and the fact that cumulative production of crude bitumen was negligible in comparison with the total resource base in 1992, crude bitumen appears very likely to replace crude oil one day as our principal source of petroleum.

The total coal resource base was estimated to be 78.8 billion tonnes in 1992, of which 6.6 billion tonnes were remaining established reserves. Data on cumulative production and other discovered or undiscovered coal resources are not available.[2] No estimates of Canada's total uranium resource base are currently available.

5.6.2 Production and consumption of energy resources

During the last 40 years, Canada has moved from consuming more energy than it produced to being a significant net producer of energy. As shown in Figure 5.6.3, the country became a net energy exporter in 1967. Since that time, primary energy production has grown to outstrip consumption by more than 50% (Table 5.6.3).[3]

Natural gas replaced crude oil as the most important primary energy source in terms of production in the late 1980s (Table 5.6.3). By 1997, it represented more than 45% of total primary energy production. The Canadian Oil Substitution Program, implemented in 1981, aided this growth in natural gas production. This program, which was abandoned in 1985, subsidized part of the cost of converting residential and commercial heating systems from oil to natural gas.[4]

1. National Energy Board, 1994, *Canadian Energy: Supply and Demand 1993-2010, Technical Report*, Catalogue No. NE23-15/3-1994E, Calgary.
2. Natural Resources Canada, 1993, *Statistical Review of Coal in Canada 1993*, Ottawa.
3. Given that Canada's principal export market is the United States, the low exchange rate of the Canadian dollar versus the U.S. dollar in the last 20 years has certainly favoured this trend. The weakness of our dollar makes our energy exports more competitive on the U.S. market.
4. Energy, Mines and Resources Canada, 1985, *Annual Report 1984–85*, Ottawa.

Table 5.6.3
Production and Consumption of Primary Energy Resources, 1958-1997

Year	Coal		Crude oil		Natural gas[1]		Electricity[2]		Total	
	Production	Consumption	Production	Consumption	Production	Consumption	Production	Consumption	Production	Consumption
	terajoules									
1958	263 975	637 271	1 020 859	1 490 275	437 088	366 256	325 683	358 649	2 047 605	2 852 451
1959	240 377	625 320	1 144 630	1 644 153	517 304	433 488	350 028	334 498	2 252 338	3 037 459
1960	244 418	559 287	1 192 301	1 715 098	624 773	496 872	381 003	362 454	2 442 495	3 133 711
1961	234 489	547 655	1 404 934	1 802 978	774 922	579 330	373 937	363 994	2 788 282	3 293 957
1962	229 599	556 731	1 601 832	1 903 300	1 044 080	661 570	374 490	369 691	3 250 001	3 491 293
1963	239 665	598 128	1 709 818	2 049 921	1 127 634	720 897	373 937	371 316	3 451 054	3 740 263
1964	253 348	620 641	1 835 513	2 091 638	1 255 120	809 498	408 360	404 624	3 752 340	3 926 401
1965	255 521	647 683	1 955 978	2 167 589	1 356 473	894 794	421 667	421 274	3 989 639	4 131 339
1966	247 496	634 962	2 136 681	2 327 897	1 466 721	981 519	467 769	463 525	4 318 667	4 407 903
1967	247 777	629 097	2 332 727	2 371 570	1 568 068	1 044 722	478 186	478 859	4 626 758	4 524 248
1968	234 133	683 468	2 520 354	2 544 142	1 776 261	1 159 897	488 768	490 434	5 019 516	4 877 941
1969	227 407	659 869	2 746 152	2 653 888	2 047 114	1 294 439	538 818	533 133	5 559 491	5 141 328
1970	354 634	708 448	3 087 416	2 860 028	2 349 711	1 418 190	567 381	558 794	6 359 142	5 545 461
1971	405 139	673 351	3 297 078	3 118 881	2 566 442	1 518 032	593 628	579 442	6 862 288	5 889 706
1972	460 770	635 417	3 803 963	3 424 584	2 899 986	1 710 604	671 751	640 604	7 836 470	6 411 208
1973	496 434	654 390	4 385 206	3 770 655	3 108 262	1 817 662	745 212	694 703	8 735 114	6 937 409
1974	526 092	664 922	4 120 340	3 930 715	3 041 698	1 850 945	808 912	762 283	8 497 041	7 208 865
1975	633 668	657 563	3 528 342	3 805 636	3 092 605	1 873 331	770 960	744 198	8 025 575	7 080 727
1976	619 975	709 029	3 235 522	3 769 982	3 107 651	1 912 329	824 819	791 664	7 787 967	7 183 004
1977	685 448	772 789	3 240 618	4 003 822	2 977 742	1 699 212	881 594	819 730	7 785 402	7 295 553
1978	743 553	788 597	3 194 640	4 017 147	3 106 827	1 957 312	948 475	878 300	7 993 495	7 641 356
1979	811 421	876 372	3 600 201	4 327 941	3 382 338	2 059 052	1 019 185	912 675	8 813 145	8 176 040
1980	891 070	928 409	3 444 041	4 216 120	3 180 730	2 116 374	1 052 072	953 991	8 567 913	8 214 894
1981	969 542	947 942	3 093 450	3 911 507	3 080 003	2 010 520	1 114 624	992 669	8 257 619	7 862 638
1982	1 028 279	1 001 681	3 052 121	3 359 122	3 163 161	2 040 386	1 093 191	980 277	8 336 752	7 381 466
1983	1 066 011	1 048 015	3 232 271	3 201 037	2 980 532	2 027 274	1 150 257	1 020 347	8 429 071	7 296 673
1984	1 396 400	1 167 377	3 430 899	3 183 745	3 311 332	2 292 108	1 235 057	1 094 325	9 373 688	7 737 555
1985	1 487 132	1 122 086	3 516 525	3 085 568	3 622 687	2 532 461	1 313 821	1 168 658	9 940 165	7 908 773
1986	1 382 118	1 039 979	3 531 205	3 055 190	3 458 952	2 480 595	1 381 010	1 258 688	9 753 285	7 834 452
1987	1 393 936	1 117 744	3 690 859	3 172 058	3 766 024	2 574 349	1 416 413	1 258 110	10 267 232	8 122 261
1988	1 614 195	1 200 307	3 877 941	3 359 461	4 313 054	2 809 862	1 390 669	1 290 430	11 195 859	8 660 060
1989	1 718 400	1 197 786	3 769 304	3 423 980	4 552 627	3 025 526	1 331 644	1 297 953	11 371 975	8 945 245
1990	1 669 347	1 077 178	3 734 823	3 463 041	4 666 451	2 918 603	1 321 983	1 320 343	11 392 604	8 779 165
1991	1 747 976	1 104 447	3 729 419	3 248 544	4 902 957	2 937 532	1 408 668	1 342 324	11 789 020	8 632 847
1992	1 545 847	1 137 075	3 884 896	3 174 778	5 394 849	3 124 340	1 414 302	1 324 117	12 239 894	8 760 310
1993	1 651 313	1 044 020	4 070 699	3 461 956	5 832 703	3 160 605	1 479 614	1 380 916	13 034 329	9 047 497
1994	1 735 269	1 086 367	4 299 874	3 604 094	6 360 250	3 281 762	1 545 925	1 387 830	13 941 318	9 360 053
1995	1 800 811	1 098 415	4 451 065	3 611 082	6 711 568	3 410 159	1 532 656	1 402 976	14 496 100	9 522 632
1996	1 832 575	1 137 887	4 591 902	3 769 295	6 950 522	3 586 701	1 586 792	1 451 230	14 961 791	9 945 113
1997	1 897 865	1 196 186	4 819 690	3 873 445	6 993 271	3 540 100	1 533 368	1 404 735	15 244 194	10 014 466

Notes:
1. Includes natural gas liquids.
2. Includes primary steam.

Source:
Statistics Canada, Environmental Accounts and Statistics Division.

Energy used in thermal-electric power production

Table 5.6.4 examines the consumption of fossil fuels in thermal-electric power stations. Since 1981, the proportion of sub-bituminous coal and lignite used has grown substantially, while that of bituminous coal (both Canadian and American) has declined. This is explained in large part by the growth in electricity production in Alberta, the province where electricity production increased the most between 1982 and 1996.[1] There was also an increase in the production of electricity from lignite in Saskatchewan. Two new lignite-burning power stations also came on-stream during this period, one in Ontario and the other in Saskatchewan.

Table 5.6.5 compares the various fuels used in fossil fuel-fired thermal power stations on the basis of energy content and greenhouse gas emission factors. See section 2.2–**Climate change** and sub-section 6.1.2–**Greenhouse gas emissions** for more information on greenhouse gases.

Map 5.6.1 portrays the regional differences in the use of coal and other fuels by thermal-electric power stations. The use of coal is particularly important in Alberta and Saskatchewan. Natural gas, which has a lower environmental impact than coal when burned, is also important in those provinces.

According to Environment Canada, the emissions of greenhouse gases attributable to thermal-electric power stations increased by more than 22% between 1990 and 1995 in

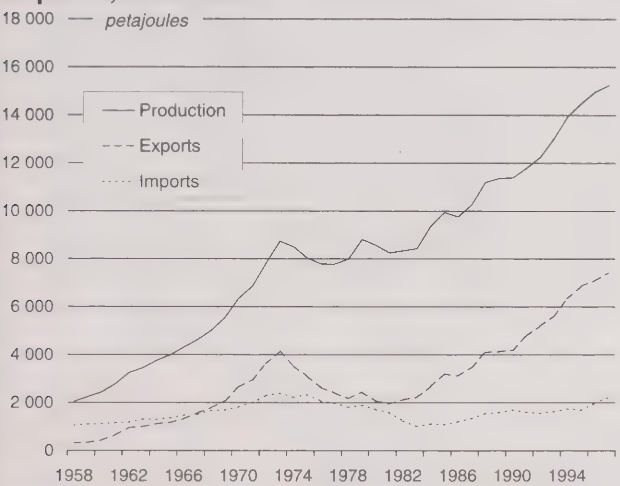
1. This trend is explained in part by the strong economic growth in Alberta during the period 1986 to 1996.

Table 5.6.4
Fuels Consumed in Thermal-electric Power Stations, 1981-1996

Year	Coal: Canadian bituminous	Coal: U.S. bituminous	Coal: Sub-bituminous	Coal: Lignite	Fuel oil: Heavy	Fuel oil: Light and diesel	Natural gas	Wood
	megatonnes				million m³		billion m³	megatonnes
1981	4.58	8.86	10.97	5.54	1.89	0.08	1.31	0.19
1982	4.51	9.68	12.67	6.77	2.01	0.06	1.11	0.26
1983	4.91	9.50	13.98	7.88	1.25	0.06	0.87	0.22
1984	5.40	10.31	15.45	9.09	1.24	0.05	0.70	0.20
1985	5.39	7.92	16.86	9.37	1.28	0.04	0.58	0.23
1986	4.70	6.42	17.29	8.03	1.12	0.05	0.42	0.29
1987	5.78	7.87	18.47	9.72	1.93	0.04	0.56	0.26
1988	6.22	8.45	19.86	11.48	2.48	0.05	1.28	0.24
1989	6.18	8.48	19.94	10.54	3.86	0.05	2.86	0.41
1990	5.84	7.97	21.01	9.71	3.36	0.06	2.07	0.34
1991	5.50	7.46	22.09	8.88	2.86	0.06	1.28	0.26
1992	6.21	6.49	21.39	9.56	3.29	0.06	2.56	0.54
1993	5.27	4.27	23.69	9.83	2.39	0.07	3.14	0.75
1994	4.32	4.54	26.08	10.27	1.88	0.06	3.25	1.46
1995	7.94	5.06	22.59	10.61	2.05	0.06	2.69	1.44
1996	4.87	5.76	25.03	10.82	1.41	0.07	1.46	0.74

Source:
Statistics Canada, Manufacturing, Construction and Energy Division, Annual Electric Power Thermal Generating Station Fuel Consumption Survey Database.

Figure 5.6.3
Primary Energy Production, Exports and Imports, 1958-1997



Source:
Statistics Canada, Environment Accounts and Statistics Division.

Saskatchewan and Alberta.[1] During this same period, electricity production in thermal power stations in these provinces increased by 14%.[2] By comparison, the corresponding figures for the entire country were 2.2% and 2.7%.

1. Jacques, A.P., F. Neitzert, and P. Boileau, 1997, *Trends in Greenhouse Gas Emissions in Canada, 1990–1995*, Environment Canada, Ottawa.
2. Statistics Canada, Manufacturing, Construction and Energy Division, Annual Electric Power Thermal Generating Station Fuel Consumption Survey Database.

Table 5.6.5
Energy Content and Emission Factors of Fuels Used in Thermal-electric Power Stations

Fuel	Unit	Energy content[1]	Emission factors: CO_2	Emission factors: CH_4	Emission factors: N_2O
		megajoules per unit	kilograms per unit	grams per unit	grams per unit
Canadian bituminous coal	kg	26.7	1.70 - 2.52	0.02	0.10 - 2.11
U.S. bituminous coal	kg	28.4	2.46 - 2.50	0.02	0.10 - 2.11
Sub-bituminous coal	kg	18.2	1.74	0.02	0.10 - 2.11
Lignite	kg	15.4	1.34 - 1.52	0.02	0.10 - 2.11
Wood	kg	18.4	1.47	0.15 - 0.50	0.16
Heavy fuel oil	l	41.6	3.09	0.03 - 0.12	0.13 - 0.40
Light fuel oil	l	37.9	2.83	0.01 - 0.21	0.13 - 0.40
Diesel	l	37.9	2.73	0.06 - 0.25	0.13 - 0.40
Natural gas	m³	38.1	1.88	4.80 - 48.0	0.02

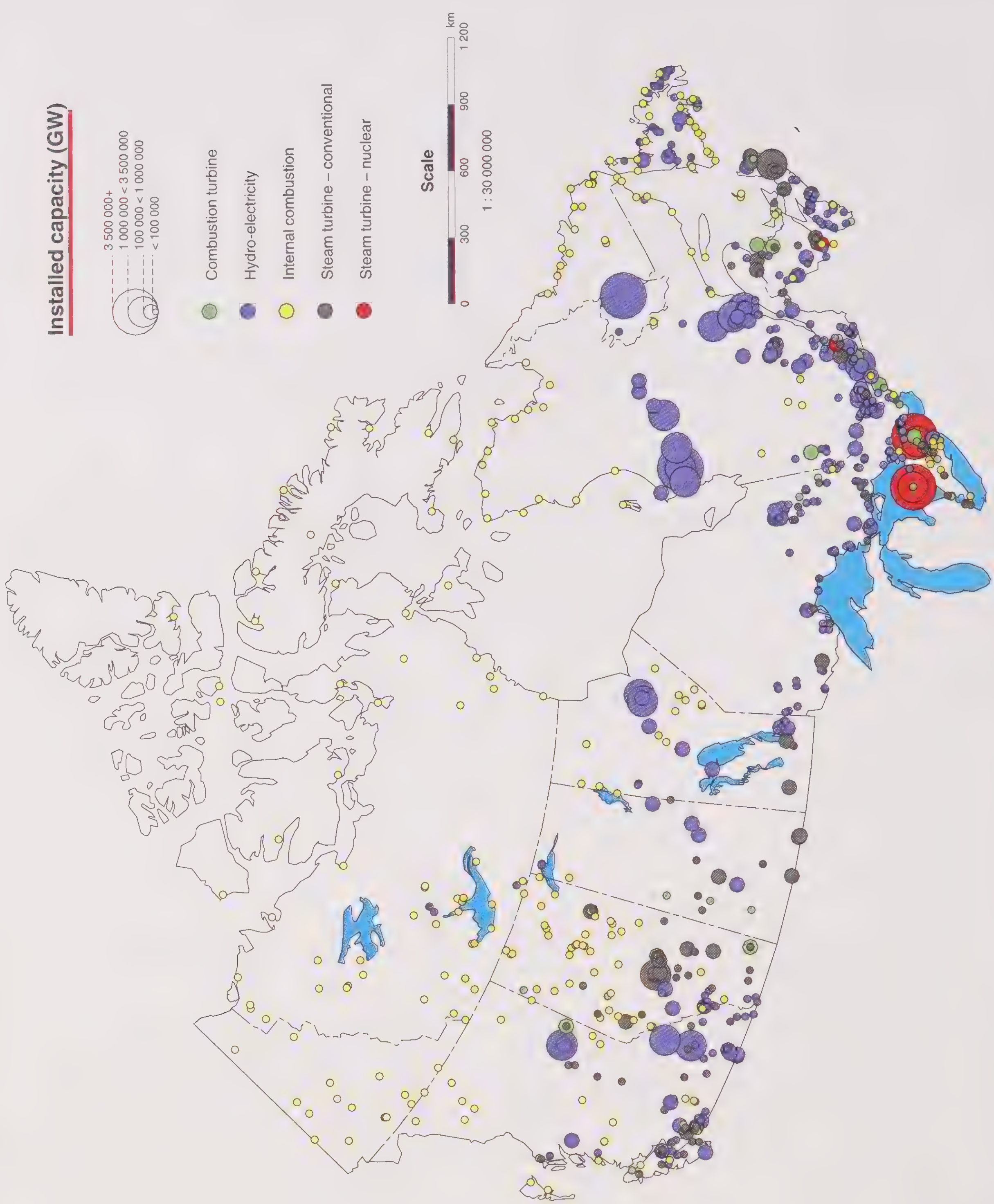
Note:
1. Average energy content reported by operators of thermal power stations over the period 1986 to 1996.

Sources:
Jacques, A.P., 1992, *Canada's Greenhouse Gas Emissions: Estimates for 1990*, Report No. EPS/5/AP/4, Environment Canada, Ottawa.
Statistics Canada, Manufacturing, Construction and Energy Division, Annual Electric Power Thermal Generating Station Fuel Consumption Survey Database.

5.6.3 Evolution of energy resource management

During the last decade, there has been a transformation in the management of energy resources. The emphasis of Canadian policies has shifted from national self-sufficiency to free trade and the deregulation of energy markets. One of the first consequences of this transition was the abandonment in the mid-1980s of most of the elements of the National Energy Program. This policy, introduced in 1973, assured a certain degree of autonomy in Canada's

Map 5.6.1
Energy Use in Electricity Production



Source:
Statistics Canada, Environment Accounts and Statistics Division.

energy supply through its principal objectives: controlling the domestic oil price and taxing oil revenues in producing provinces with the aim of distributing this income among all provinces.[1]

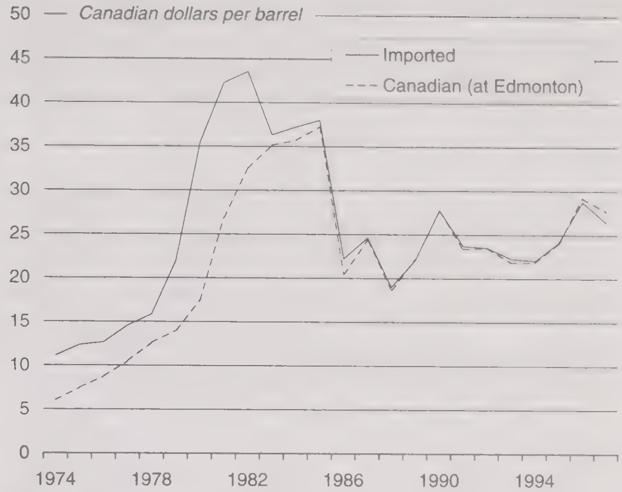
Provincial equalization payments[2] were also used to redistribute energy resource revenues from provinces rich in these resources to those with none. Prior to 1982, the formula used to calculate equalization payments included revenues associated with energy resource exploitation (such as licence fees and payments for exploration rights and royalties, for example).[3] As a result, each time the price of oil increased, equalization payments from oil-rich to oil-poor provinces increased. Since this formula changed in 1982, the fluctuations in oil prices have had little impact on equalization payments.

Energy prices

As a result of the National Energy Program policy of price controls, the domestic oil price was maintained below the world price in the 1970s and early 1980s. This policy was enforced both for imports and for domestic production. The federal government made up the difference between the world oil price facing Canadian importers and the lower domestic price they could charge for their oil.

1. Other programs introduced in the early 1980s were financial assistance for home insulation (abandoned in 1986) and the Canadian Oil Substitution Program.
2. Equalization payments are made by the federal government to certain provinces in order to reduce differences in government revenue per capita between wealthy and less wealthy provinces.
3. Plourde, André, 1990, "Les enjeux de la politique énergétique canadienne des années quatre-vingts," Research paper #9005, Department of Economics, Faculty of Social Sciences, University of Ottawa.

Figure 5.6.4
Crude Oil Prices, 1974-1997



Sources:
Natural Resources Canada.
Statistics Canada, CANSIM, matrix 2491.

After price controls were abandoned in 1985, the domestic petroleum price quickly aligned itself with the world price (Figure 5.6.4). World crude oil prices dropped dramatically in 1986 and Canadian oil and refined petroleum product prices followed suit. In contrast, those for coal and natural gas remained essentially stable, while electricity prices followed a general upward trend (Table 5.6.6).

The stagnation in the prices of most energy commodities is striking when one compares it with the evolution of the prices of other factors of production, such as labour, equipment and non-energy raw materials. Over the period 1983 to 1996, prices of these factors rose by at least 40%.

Table 5.6.6
Energy Prices, 1983 and 1996

	Coal[1]											
	Canadian bituminous		U.S. bituminous		Sub-bituminous		Lignite		Natural gas		Electricity	
Province/Territory	1983	1996	1983	1996	1983	1996	1983	1996	1983	1996	1983	1996
	dollars per tonne								cents per m³		cents per kilowatt hour	
Newfoundland	...	...	...	...	...	...	...	...	...	...	3.7	4.8
Prince Edward Island	...	...	...	...	...	...	...	...	...	...	12.3	10.8
Nova Scotia	43.8	69.3	...	...	...	...	...	...	...	...	6.9	8.1
New Brunswick	63.1	103.2	...	58.2	...	...	...	...	34.1	...	5.4	6.3
Quebec	...	...	...	...	...	...	...	...	19.1	17.3	3.4	4.8
Ontario	86.6	51.1	64.0	58.2	...	...	41.4	32.1	18.0	17.1	3.9	7.3
Manitoba	...	...	...	...	...	32.0	20.2	20.7	15.8	15.8	3.1	4.9
Saskatchewan	...	...	...	...	25.1	...	8.7	11.6	12.2	14.8	4.2	6.4
Alberta	4.7	9.0	...	...	8.5	9.8	...	...	9.3	8.3	5.2	5.6
British Columbia	...	...	...	...	...	...	...	...	14.2	16.6	3.8	5.0
Yukon Territory	...	...	...	...	...	...	...	...	...	...	8.3	10.6
Northwest Territories	...	...	...	...	...	...	...	...	...	...	17.9	23.2
Canada	**62.1**	**61.6**	**64.0**	**58.2**	**8.5**	**9.8**	**13.9**	**13.8**	**14.6**	**13.6**	**3.9**	**5.9**

Note:
The absence of a price in a particular province means that energy type is not used (or used very little) in that province.
1. Coal prices are those paid by thermal-electric power stations, which are the principal consumers of this energy resource.
Sources:
Natural Resources Canada.
Statistics Canada, 1996, *Electric Power Generation, Transmission and Distribution*, Catalogue No. 57-202-XPB, Ottawa.

The divergence between the prices of most energy commodities and non-energy inputs may explain the absence of gains in energy efficiency witnessed since the mid-1980s. As seen in Table 5.6.1, there has been little change since that time in the quantity of energy required per dollar of GDP.

Electricity prices

Electricity stands out as an exception among energy resources, with prices having increased significantly across Canada since the 1980s. Although price increases vary across the country, they were high enough in general to explain the fact that the electric power industry is under pressure to restructure, particularly in provinces like Ontario where rate increases have been very high (Text Box 5.6.1).

Electricity production is mainly carried out in Canada by public utilities owned by provincial governments. These utilities have been traditionally vertically integrated; that is, they have taken care of all three aspects of electricity supply: production, transmission and distribution.[1]

The increases in electricity prices have probably played an important role in driving deregulation of the industry and introducing competition into the market. So too have the recent experiences with deregulation in other countries.[2] One of the objectives of deregulation is to allow a greater degree of independence in each of the three aspects of energy supply and, eventually, to allow competition in the production of electricity.[3]

Text Box 5.6.1
Deregulation of the Electric Power Industry

Electricity generation is generally a provincial responsibility in Canada. Deregulation of the market is at various stages of advancement, depending upon the province in question.

- In Alberta, competition has been introduced in the wholesale electricity market.
- In British Columbia, the focus is currently on allowing greater trade in electricity, particularly with the United States.
- In Ontario, deregulation legislation was adopted in the fall of 1998. Its intent is to separate the transmission of electricity from its production and distribution, to create a competitive market for electricity retailing, and to allow competition in electricity production.
- In Quebec, a provincial energy board has been created out of the existing provincial natural gas board. In addition to its previous tasks, the new board is also responsible for surveillance of Hydro-Québec's operations and for consumer protection.

1. 'Transmission' is defined as transport of electricity over high-voltage lines (at least 50 kilovolts); transport over lower-voltage lines is considered to be 'distribution.'
2. Notably in New Zealand, Australia, Chile, Argentina, England, Norway and the United States (California and New York State).
3. Doucet, J.A., 1997, *La restructuration des marchés de l'électricité : un portrait de la situation mondiale*, Groupe de recherche en économie de l'énergie et des ressources naturelles, Université Laval, Québec.

5.7 Mineral resources

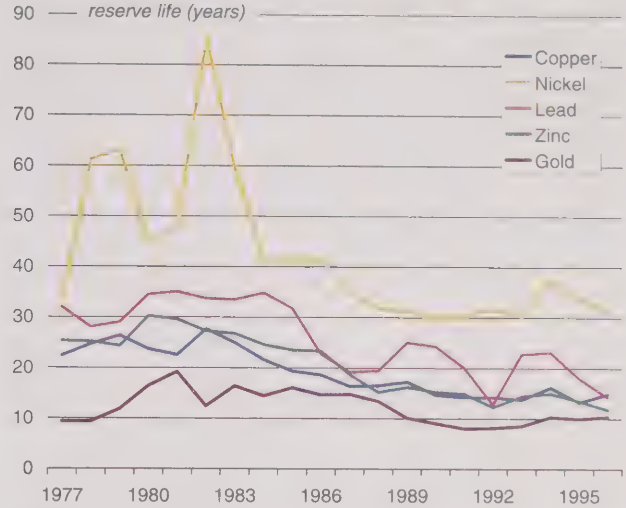
The increasing use of non-renewable mineral resources (see Figure 4.7.1 in section 4.7–**Mineral industries**) raises the obvious question about the availability of resources, as well as related questions about recycling and the possibility of substitution for these resources. This section examines the stocks of selected mineral resources and their use in the Canadian economy.[1] Figures pertaining to global production and consumption are also presented since the production of many minerals in Canada, from both mines and refineries, far exceeds domestic use.

5.7.1 Stocks and flows[2]

Estimates of the stock of mineral resources are based on knowledge of both the existence of the resource and the feasibility of profitably extracting it. This stock is generally measured in terms of reserves. Estimates of Canada's reserves of non-ferrous metals are based on the metal content of material that is considered proven or probable in deposits that are either already in production or firmly committed to production.[3] Proven and probable reserves are the part of a resource that is known to exist with a very high degree of certainty through drilling and sampling, and that can be extracted profitably at current prices and with available technology.

With the exception of gold, Canada's reserves of a number of major metals declined steadily from the early 1980s until the mid-1990s (Table 5.7.1). The decline in reserves reflects metal price decreases. Copper and nickel prices, for example, fell by one-third during the early 1980s; this reduced the size of reserves since some could no longer be extracted profitably and also discouraged exploration activity. The estimated reserve life for selected minerals is presented in Figure 5.7.1.[4]

Figure 5.7.1
Reserve Life of Selected Metals, 1977-1996



Source:
Statistics Canada, Environment Accounts and Statistics Division.

Table 5.7.1
Reserves of Selected Major Metals, 1977-1996

	Copper	Nickel	Lead	Zinc	Gold	Silver
			thousand tonnes			
1977	16 914	7 749	8 954	26 953	0.5	31
1978	16 184	7 843	8 930	26 721	0.5	31
1979	16 721	7 947	8 992	26 581	0.6	32
1980	16 714	8 348	9 637	27 742	0.8	34
1981	15 511	7 781	9 380	26 833	0.9	32
1982	16 889	7 546	9 139	26 216	0.8	31
1983	16 214	7 393	9 081	26 313	1.2	31
1984	15 530	7 191	9 180	26 000	1.2	31
1985	14 201	7 041	8 503	24 553	1.4	29
1986	12 918	6 780	7 599	22 936	1.5	26
1987	12 927	6 562	7 129	21 471	1.7	25
1988	12 485	6 286	6 811	20 710	1.8	26
1989	12 082	6 092	6 717	20 479	1.6	24
1990	11 261	5 776	5 643	17 847	1.5	20
1991	11 040	5 691	4 957	16 038	1.4	18
1992	10 755	5 605	4 328	14 584	1.3	16
1993	9 740	5 409	4 149	14 206	1.3	16
1994	9 533	5 334	3 861	14 514	1.5	19
1995	9 250	5 832	3 660	14 712	1.5	19
1996	9 667	5 623	3 450	13 660	1.7	19

Source:
Natural Resources Canada, *Canadian Minerals Yearbook*, <http://www.nrcan.gc.ca/mms/cmy/index_e.html>, (accessed June 21, 1999).

A broader measure of resource stocks is published by the United States Geological Survey (USGS). This measure, the reserve base, includes resources that are known with less certainty and those that, although currently not mineable at a profit, are considered to have a reasonable potential for profitable extraction. The reserve base estimated for Canadian minerals is typically at least twice as large as the estimate of proven and probable reserves (Table 5.7.2).

1. Fossil fuel resources are covered in section 5.6–**Energy resources**, while economic and exploration data pertaining to mineral resources are presented in section 4.7–**Mineral industries**.
2. Throughout this section, the primary reference for each of the metal profiles is indicated by the footnote to the profile heading. Other references are indicated in the text.
3. Reed, A., 1997, "Canadian Reserves of Selected Major Metals, and Recent Production Decisions," in Natural Resources Canada, *Canadian Minerals Yearbook: Review and Outlook*, <http://www.nrcan.gc.ca/mms/cmy/CMY_E2.html>, (accessed August 17, 1999), Minerals and Metals Sector, Ottawa, pp. 2.1-2.15. Note that reserves of iron are not included because they are too abundant to be analysed on the same level as the rarer non-ferrous metals.
4. Reserve life is estimated by dividing the estimated proven and probable mineral reserves at year-end by the volume of mineral production during that year. It is important to note that several factors can contribute to increasing or decreasing reserve life from year to year (including changes in technology, prices, reserve size, and extraction rates). The reserve life figures for Canada are based on the reserves reported in the *Canadian Minerals Yearbook* and the mineral production figures from CANSIM found in Table 5.7.3.

Table 5.7.2
Reserves and Reserve Base of Selected Metals, 1998

	Iron ore	Aluminum (bauxite)	Copper	Zinc	Lead	Nickel
			thousand tonnes			
Canada						
Reserves	1 100 000	...	10 000	14 000	3 500	5 300
Reserve base	2 500 000	...	23 000	39 000	12 000	15 000
World						
Reserves	74 000 000	25 000 000	340 000	190 000	66 000	40 000
Reserve base	160 000 000	34 000 000	650 000	440 000	140 000	140 000

Source:
United States Geological Survey, *Commodity Statistics and Information*, <http://minerals.usgs.gov/minerals/pubs/commodity>, (accessed August 17, 1999).

Iron and steel[1]

Iron is the least expensive and most widely used metal. Pig iron, produced by smelting iron ore in a blast furnace, is a brittle material because of its high carbon content. In Canada and the United States, blast furnaces are part of integrated steel production, in which molten iron is transferred from a blast furnace directly to a basic oxygen furnace where it is refined to produce steel.[2] Electric furnaces (minimills) that melt scrap steel have become an increasingly important alternative method of producing steel and now account for half of Canada's steel production.[3]

Iron is used by foundries to make cast products such as engine cylinder blocks. Steel, which corrodes easily, is often coated with a corrosion-resistant material such as zinc or tin in a process called galvanizing. Steel is also alloyed with other metals such as chrome, nickel or manganese to enhance its resistance to corrosion and extreme temperatures, or to produce stronger or harder materials such as tool steel. Canada's apparent consumption of steel was 17 million tonnes in 1997.[4] The automotive, construction, and oil and gas industries (including refineries and pipelines) together account for about 70% of steel demand in Canada. Other major uses are other transportation equipment, industrial and agricultural equipment, and cans and other containers.

From 1970 to 1997, world production of primary iron (from iron ore) remained almost constant, but production by area has shifted, declining in the Commonwealth of Independent States, North America and Europe, and increasing in Asia.[5] Asia's share of world production almost doubled to 45% during this period.[6] World production of primary iron was 550 million tonnes in 1997, and steel production was 795 million tonnes.[7] Canada's steel production in 1997 was 17 million tonnes, with 8.5 million tonnes of scrap steel input.[8]

World production of iron ore exceeded one billion tonnes in 1997.[9] China accounted for about one-quarter of this total. In 1998 world reserves of iron ore were equivalent to over 100 years of mine production.[10]

Copper[11]

Copper, a good conductor of heat and electricity, is alloyed with zinc to produce brass. Preliminary 1996 data for copper use in the United States show that building construction accounted for about 43% of the end use of copper (in electrical and telecommunications wiring, and plumbing and heating and cooling equipment), electrical and electronic products for 24%, industrial machinery and equipment and transportation equipment for 12% each, and consumer and other products for the remaining 9%.[12] Some of the substitutes for copper are aluminum in products such as electrical wire and cable, automobile radiators, and heating and cooling equipment; optical fibre in telecommunications cable; and plastics in plumbing pipe and fixtures.[13] Recycled copper accounted for 24% (136 thousand tonnes) of the total amount of metal refined in Canada in 1997.[14] Consumption of copper in Canada, 225 thousand tonnes in 1997, is about one-half of refinery production.

1. Miron, M., 1998, "Iron Ore," in Natural Resources Canada, *Canadian Minerals Yearbook: Review and Outlook*, <http://www.nrcan.gc.ca/mms/cmy/CMY_E3.html>, (accessed August 17, 1999), Minerals and Metals Sector, Ottawa, pp. 27.1–27.5.
2. The carbon is removed when it combines with oxygen blown onto the molten iron.
3. Canadian Steel Producers Association, 1999, *Press Release: Steel Facts 1995–1998*, <http://www.canadiansteel.ca/industry/steel_facts_95_98.html>, (accessed May 14, 1999).
4. *Ibid.* Apparent consumption is producers' shipments plus imports minus exports.
5. United States Geological Survey, 1999, *Commodity Statistics and Information: Iron Ore*, <http://minerals.usgs.gov/minerals/pubs/commodity/>, (accessed August 17, 1999), Reston, Virginia.
6. *Ibid.*
7. *Ibid.*
8. Canadian Steel Producers Association, 1999, *op. cit.*
9. Miron, M., 1998, *op. cit.*
10. World reserve life is estimated from the production and reserve figures provided by the United States Geological Survey in its *Mineral Commodity Summaries*.
11. Bokovay, G., 1998, "Copper," in Natural Resources Canada, *op. cit.*, pp. 21.1–21.24.
12. Copper Development Association Inc., cited in Bokovay, 1998, *op. cit.*
13. United States Geological Survey, 1999, *Mineral Commodity Summaries: Copper*, <http://minerals.usgs.gov/minerals/pubs/commodity/>, (accessed August 17, 1999), Reston, Virginia.
14. World Bureau of Metal Statistics, 1999, *World Metal Statistics*, Vol. 52, No. 7, London, England.

Table 5.7.3
Mineral Production, 1948-1998

	Non-fuel minerals								
Year	Copper	Nickel	Lead	Zinc	Iron ore	Gold	Potash	Salt	Gypsum
	thousand tonnes								
1948	218	119	152	212	1 213	0.110	-	672	2 916
1949	239	117	145	262	3 334	0.128	-	679	2 735
1950	240	112	150	284	3 271	0.138	-	779	3 325
1951	245	125	144	309	4 246	0.137	-	875	3 450
1952	234	127	153	337	4 783	0.139	-	882	3 255
1953	230	130	176	364	5 906	0.126	-	866	3 483
1954	275	146	198	342	6 679	0.136	-	880	3 584
1955	296	159	184	393	14 772	0.141	-	1 129	4 234
1956	322	162	171	384	20 274	0.136	-	1 443	4 440
1957	326	170	165	375	20 205	0.138	-	1 607	4 151
1958	313	127	169	386	14 267	0.142	-	2 155	3 596
1959	359	169	169	359	22 215	0.139	-	2 985	5 335
1960	398	195	186	369	19 550	0.144	-	3 007	4 722
1961	398	211	209	377	18 469	0.139	-	2 945	4 478
1962	415	211	195	420	24 820	0.130	-	3 301	4 836
1963	416	200	184	424	27 300	0.124	-	3 377	5 409
1964	444	207	185	611	34 857	0.118	-	3 618	5 770
1965	463	242	268	747	36 181	0.112	1 335	4 159	5 718
1966	461	203	276	872	36 914	0.102	1 979	3 746	5 421
1967	547	224	285	994	37 788	0.092	2 389	4 532	4 549
1968	575	240	309	1 052	43 040	0.085	2 576	4 413	5 378
1969	520	194	289	1 096	36 337	0.079	3 161	4 199	5 782
1970	610	278	353	1 136	47 458	0.075	3 108	4 919	5 733
1971	654	267	368	1 134	42 957	0.070	3 558	5 061	6 081
1972	720	235	335	1 129	38 736	0.065	3 495	4 902	7 349
1973	824	249	342	1 227	47 499	0.061	4 454	5 047	7 610
1974	821	269	294	1 127	46 784	0.053	5 776	5 447	7 226
1975	721	240	315	1 004	44 742	0.051	4 726	5 123	5 746
1976	731	241	256	982	55 416	0.053	5 215	5 994	6 003
1977	759	233	281	1 071	53 621	0.054	5 764	6 039	7 231
1978	659	128	320	1 067	42 931	0.054	6 344	6 452	8 074
1979	636	126	311	1 100	59 617	0.051	7 074	6 881	8 099
1980	710	188	280	920	50 224	0.049	7 225	7 226	7 285
1981	691	160	269	911	49 551	0.047	6 549	7 239	7 025
1982	613	89	272	966	33 198	0.065	5 309	7 930	5 986
1983	653	125	272	988	32 959	0.074	6 294	8 602	7 507
1984	722	174	264	1 063	39 930	0.083	7 527	10 235	7 775
1985	739	170	268	1 049	39 502	0.088	6 661	10 085	7 761
1986	699	164	334	988	36 167	0.103	6 753	10 740	8 802
1987	794	189	373	1 158	37 804	0.116	7 668	10 129	9 095
1988	758	199	351	1 370	39 934	0.135	8 154	10 687	9 513
1989	704	196	269	1 273	39 445	0.159	7 014	11 158	8 195
1990	771	195	233	1 179	35 670	0.167	7 345	11 191	7 977
1991	780	188	248	1 083	35 917	0.175	7 087	11 871	6 729
1992	762	178	340	1 196	32 137	0.160	7 040	11 088	7 293
1993	711	178	183	991	33 774	0.153	6 880	10 993	7 564
1994	591	142	168	976	36 728	0.146	8 517	12 244	8 586
1995	701	172	204	1 095	37 024	0.151	8 855	10 957	8 055
1996	653	182	242	1 163	34 709	0.165	8 120	12 248	8 201
1997	648	181	171	1 027	39 293	0.171	9 235	13 497	8 628
1998	688	195	151	992	37 380	0.164	8 813	13 041	8 115

Note:
Annual production of metallic minerals refers to the metal content of the ore mined, with the exception of iron ore where the quantity of ore mined is the determining factor.
Source:
Statistics Canada, CANSIM, matrices 9,13,14,19 and 20.

In 1996 Canada's copper reserves were equivalent to 15 years of mine production. In 1998 world reserves of copper were equivalent to 29 years of production. World consumption of refined copper in 1997 was 13.1 million tonnes,[1] over four times the consumption in 1950.[2]

Zinc[3]

Almost 60% of the zinc consumed in Canada in 1997 was used for galvanizing (coating steel for protection from corrosion). The automobile industry is a major user of galvanized steel since corrosion protection allows the use of thinner-gauge steel to reduce weight. Galvanized steel is also extensively used in buildings (concrete reinforcement bars, roofing and siding) and other structures such as transmission towers for electricity. The second most important use of zinc (19%) is the manufacture of brass and bronze for use in products such as plumbing fittings or heating and air conditioning equipment. Zinc dust, oxides and other compounds have a wide variety of applications, from pharmaceutical use as an ointment to industrial use as an accelerator in curing rubber. In 1997 production of refined zinc in Canada (0.7 million tonnes) represented 9% of world refinery production.

Canada produces about 14% of the world's zinc ore and is the world's second-largest producer after China. Canada's reserves in 1996 were equivalent to 12 years of mine production. World reserves were equivalent to 24 years of production in 1998. World zinc use in 1997 (7.7 million tonnes)[4] was almost four times greater than in 1950.[5]

Lead[6]

The predominant use of lead in the western world (70%) is in the production of lead–acid batteries, primarily for automobiles. Some of its other applications are in making solder, pigments and some types of glass. Health and environmental concerns have led to a decline in the use of lead in some products such as gasoline, solder for plumbing, and paint. Recycled lead accounted for 48% (132 thousand tonnes) of the metal produced by Canadian refineries in 1997.[7]

Canada's reserves of lead in 1996 represented 14 years of annual production. World reserves were equivalent to 22 years of production in 1998. World lead consumption was 5.8 million tonnes in 1997,[8] or three times the consumption in 1950.[9]

Nickel[10]

Worldwide, about two-thirds (63%) of the nickel produced in 1997 was used to manufacture stainless steel.[11] Other important uses of nickel are non-ferrous alloys, electroplating and other steel alloys. Nickel-bearing stainless steel and other nickel alloys are resistant to corrosion and to temperature extremes. Stainless steel and nickel alloys are used in a wide range of products such as gas turbines, chemical and food-processing equipment, surgical equipment, building materials, and household utensils and appliances. Nickel–cadmium and nickel–metal–hydride batteries are other uses of nickel. There are few substitutes for nickel that offer a comparable combination of strength and resistance to heat and corrosion at the same cost.

In 1997 Canadian mine production accounted for about 17% of world nickel ore production. Canada is the second-largest producer of nickel ore after Russia. In 1996 Canada's reserves of nickel were equivalent to 31 years of production. World reserves were equivalent to 34 years of production in 1998. World consumption of nickel approached one million tonnes in 1997,[12] slightly more than six times the level of consumption in 1950.[13]

Aluminum[14]

Aluminum is light, easily machined, corrosion resistant and a good conductor of electricity and heat. It can be combined with copper, magnesium, manganese, silicon or zinc to produce alloys with greater tensile strength, hardness or corrosion resistance. Transportation equipment (aircraft fuselages, ship superstructures and automobile radiators and wheels, for example) accounted for 26% of world aluminum use in 1998, while packaging (including cans) and buildings/other construction each accounted for 20%. Canada's 1997 production, estimated at 2.3 million tonnes, ranked third after the United States (3.6 million tonnes) and Russia (2.9 million tonnes). Approximately 4% of the refined aluminum produced in Canada is made from recycled material.[15]

1. World Bureau of Metal Statistics, 1999, *World Metal Statistics*, Vol. 52, No. 7, London, England.
2. Metaleurop, 1995, *Annuaire Statistique/Statistical Yearbook 1994*, Fontenay-Sous-Bois, France.
3. Chevalier, P., 1998, "Zinc," in Natural Resources Canada, *Canadian Minerals Yearbook: Review and Outlook*, <http://www.nrcan.gc.ca/mms/cmy/CMY_E3.html>, (accessed August 17, 1999), Minerals and Metals Sector, Ottawa, pp. 62.1–62.18.
4. World Bureau of Metal Statistics, 1999, *op. cit.*
5. Metaleurop, 1995, *op. cit.*
6. Keating, J., 1997, "Lead," in Natural Resources Canada, *op. cit.*, pp. 28.1–28.14.
7. World Bureau of Metal Statistics, 1999, *op. cit.*
8. *Ibid.*
9. Metaleurop, 1995, *op. cit.*
10. McCutcheon, B., 1998, "Nickel," in Natural Resources Canada, *op. cit.*, pp. 37.1–37.22.
11. Inco Limited, cited in McCutcheon, B., 1998, *op. cit.*
12. World Bureau of Metal Statistics, 1999, *op. cit.*
13. Metaleurop, 1995, *op. cit.*
14. Wagner, W., 1998, "Aluminum," in Natural Resources Canada, *op. cit.*, pp. 8.1–8.26.
15. World Bureau of Metal Statistics, 1999, *op. cit.*

Although aluminum is an abundant element, bauxite is the only ore from which it can be economically produced. Bauxite is refined to produce alumina, and aluminum smelters capture aluminum from dissolved alumina by electrolysis. This requires a significant input of electricity.

Bauxite is not mined in Canada, so there are no domestic reserves. Rather, aluminum production in Canada is based on the availability of significant quantities of electric power. Aluminum is important to the country since Canada is one of the world's leading producers of the refined metal. The aluminum ore used in Canada is imported mostly from Brazil, Guinea, Australia and Guyana. In 1998 world reserves of bauxite were equivalent to about 200 years of mine production. World consumption of aluminum was 22 million tonnes in 1997,[1] about 14 times the consumption in 1950.[2]

Potash[3]

Canada is the world's leading producer and exporter of potassium chloride, the dominant mineral in the group of potassium-bearing compounds collectively known as potash. Its main use is in agricultural fertilizer, which accounted for 94% of world demand in 1997. Canada's 1997 exports of potash accounted for 44% of all international trade in the mineral. The primary markets for this trade were the United States (60%) and Asia (25%).

Canada's potash reserves are abundant, and the reserve life of the resource is estimated to be several hundred years.[4]

Stone, sand and gravel[5]

The quantity of sand and gravel used in 1996 was 215 million tonnes. The main uses were roads (56%), concrete aggregate (13%) and asphalt aggregate (9%). The use of crushed stone, 83 million tonnes in 1996, followed a similar pattern: roads (44%), asphalt aggregate (13%) and concrete aggregate (12%). Crushed stone accounted for most of the stone used, although significant quantities were used to make cement (14 million tonnes) and lime (5 million tonnes). Resources of stone, sand and gravel are abundant, although local shortages could exist, and access to these resources near urban areas could be restricted.

Salt[6] and gypsum[7]

Apparent consumption of salt in Canada is approximately 9 million tonnes annually. About half of this is used to de-ice roads. The manufacture of chemicals such as chlorine and caustic soda is another major use. Trade in salt worldwide is small relative to production because salt is abundant and the cost of extraction is small compared with the cost of transportation. Canada ranked fourth in world production of salt in 1995.

Most of the approximately 3 million tonnes of gypsum consumed annually in Canada is used as wallboard. It is also used as an ingredient in cement, as a soil additive in agriculture, and as a filler in plastics, paint and paper. Canada's reserves are estimated to be the equivalent of more than 50 years of production.

1. World Bureau of Metal Statistics, 1999, *World Metal Statistics*, Vol. 52, No. 7, London, England.
2. Metaleurop, 1995, *Annuaire Statistique/Statistical Yearbook 1994*, Fontenay-Sous-Bois, France.
3. Prud'homme, M., 1998, "Potash," in Natural Resources Canada, *Canadian Minerals Yearbook: Review and Outlook*, <http://www.nrcan.gc.ca/mms/cmy/CMY_E3.html>, (accessed August 17, 1999), Minerals and Metals Sector, Ottawa, pp. 41.1–41.15.
4. United States Geological Survey, 1999, *Commodity Statistics and Information: Potash*, <http://minerals.usgs.gov/minerals/pubs/commodity>, (accessed August 17, 1999), Reston, Virginia.
5. Vagt, O., 1998, "Mineral Aggregates," in Natural Resources Canada, *op. cit.*, pp. 34.1–34.10.
6. Morel-à-l'Huissier, P., 1998, "Salt," in Natural Resources Canada, *op. cit.*, pp. 49.1–49.13.
7. Vagt, O., 1997, "Gypsum and Anhydrite," in Natural Resources Canada, *op. cit.*, pp. 25.1–25.9.

6 Ecosystems and Well-being

Introduction

Human activity has had a profound impact on the structure and function of many ecosystems. Natural areas are physically altered by agriculture, forestry, natural resource extraction, urbanization and transportation networks. Together with pollution and the introduction of exotic species, these factors have contributed to loss of habitats and extinction of animal and plant species.

Within the past two centuries, impacts of human activities have grown from occasional, localized problems to the point where pollution often reaches levels that are hazardous to the health of humans and other living organisms. Whether these impacts are considered major or minor is largely a question of our understanding of the relationships between human stresses on the environment and ecosystem responses.

However, not all changes in the environment are the result of human activities. The natural cycle inherent in climatic systems and the fluctuations of wildlife populations provide a background from which to assess the magnitude of human-induced impacts.

Understanding the ways human activities alter the natural environment is an important step in reducing their impact.

Map 6.1
Environmental Quality Highlights

6.1 Waste generation and management

Despite the fact that waste generation and management are recognized problems in Canada, relatively few statistics are available on the quantities and types of wastes we produce. The most reliable and comprehensive of those statistics available have been compiled in this section.

6.1.1 Radioactive wastes

Radioactive wastes are classified as either high-level or low-level. High-level radioactive wastes (HLRW) are those created when used nuclear fuel bundles are removed from nuclear reactors.[1] Low-level radioactive wastes (LLRW) come from a variety of sources; the extraction of uranium ore and the processing of uranium and other radioactive materials are the main contributors.

The Atomic Energy Control Board regulates the activities that produce HLRW and LLRW and the management of the wastes themselves.

High-level radioactive wastes[2]

Used nuclear fuel bundles emit high levels of both penetrating (gamma) and particle (alpha and beta) radiation when they are removed from nuclear reactors.

Gamma radiation can penetrate deep into human tissue and destroy or interfere with cells. The effects of this penetration, ranging from increased cancer risks to death, depend upon the degree of exposure (see Table 6.5.1 in section 6.5–**Contaminants in biota**).

Used nuclear fuel bundles emit dangerous levels of gamma radiation when first removed from reactors. After about 500 years, these emissions decay to nearly safe levels.

Unlike gamma radiation, alpha- and beta-particle radiation harm humans only when substances emitting these particles are ingested (for example, if grains of radioactive material from used fuel bundles were to leach into groundwater and eventually appear in drinking water supplies). Also unlike gamma radiation, alpha- and beta-particle emissions from used fuel bundles remain dangerous for tens of thousands of years.

1. Canada's CANDU nuclear reactors use fuel rods of uranium dioxide packed into bundles to generate electricity. Each of these bundles weighs 20 kilograms and is approximately the size of a fireplace log. However, they pack a bit more punch than the average fireplace log: one of them provides enough energy to heat a home in northern Canada for about 100 years.
2. Unless otherwise cited, this section is based on Atomic Energy Control Board, *Regulating Nuclear Fuel Waste*, INFO-0537(E), Ottawa.

Table 6.1.1
Spent Nuclear Fuel Bundles in Storage by Province, 1992, 1995 and 1997

	1992	1995	1997
	kilograms of uranium		
Dry storage			
New Brunswick	255 285	472 189	650 525
Quebec	67 596	180 101	465 151
Ontario	307 470	307 092	715 544
Canada	**630 351**	**959 382**	**1 831 220**
Wet storage			
New Brunswick	750 256	766 125	747 300
Quebec	744 461	914 565	812 174
Ontario	15 145 613	19 505 430	21 681 207
Canada	**16 640 330**	**21 186 121**	**23 240 681**
Total storage			
New Brunswick	1 005 541	1 238 314	1 397 825
Quebec	812 056	1 094 666	1 277 325
Ontario	15 453 083	19 812 522	22 396 751
Canada	**17 270 681**	**22 145 502**	**25 071 901**

Source:
K. Brag, Atomic Energy Control Board, personal communication.

Because of the danger they pose, used fuel bundles are stored in one of two types of highly controlled facilities. Initially, all used bundles are placed in water-filled tanks (wet storage) following their removal from a reactor. There they remain for a minimum of five years. The water allows the bundles to cool while preventing radiation from escaping into the surrounding environment. After five years in wet storage, the bundles may either remain in wet storage or be moved to concrete canisters for dry storage above ground.

As illustrated in Table 6.1.1, at the end of 1997, nearly 93% of the used nuclear fuel stored in Canada was in wet storage facilities.

Environmental effects of nuclear power generation

A number of negative environmental effects are associated with nuclear power generation. These are summarized in Text Box 6.1.1. When compared with other electricity generation methods, however, nuclear power has relative environmental advantages. For example, Table 6.1.2 compares nuclear power with coal generation across several categories of environmental impact.

Table 6.1.2
Nuclear Power vs. Coal Power

	1-gigawatt station	
	Coal	Nuclear
Land use (hectares)	70	20
Annual fuel use (megatonnes)	1 134	0.057
Annual waste production (megatonnes)		
Ash	272	-
Carbon dioxide	2 722	-
Sulphur dioxide	45	-
Nitrous oxide	7	-
Used fuel (high-level radioactive waste)	-	0.057
Mine tailings	-	11

Source:
The Canadian Nuclear Association, 1991, *Nuclear Facts: Seeking to generate a better understanding*, No. 21-1991, Toronto.

Text Box 6.1.1
Environmental Considerations in Nuclear Electricity Production

Activity	Environmental considerations/effects
Uranium mining	land subsidence requirement for land reclamation low-level radioactive dust release low-level radioactive waste disposal disposal of mine drainage water underground water contamination
Uranium treatment/milling	mill tailings containing toxic metals liquid and solid chemical wastes low-level radioactive milling wastes low-level radioactive dust releases high water consumption waste heat releases
Electricity generation	gaseous radionuclide emissions liquid radionuclide emissions high-level radioactive wastes decontamination and decommissioning waste heat releases

Source:
Organisation for Economic Co-operation and Development (OECD), 1985, *Environmental Effects of Electricity Generation,* Paris.

Low-level radioactive wastes

Low-level radioactive wastes come from a variety of sources. The mining and milling of uranium ore is a major source, as are the nuclear fuel cycle,[1] radioisotope production and the decommissioning of nuclear generating and research stations.

Table 6.1.3 provides a regional breakdown of tailings stored at major uranium mining and milling sites in Canada. As of 1999, approximately 204.8 megatonnes of tailings were in storage, covering 1 570 hectares.

Table 6.1.3
Uranium Mine and Mill Tailings by Region, 1999

Region	Waste quantity	Area covered	Status of site
	megatonnes	hectares	
Ontario			
Bancroft area	6.4	51	inactive
Elliot Lake area - north	168.0	1 088	inactive
Elliot Lake area - south	7.5	63	inactive
Saskatchewan			
North of Lake Athabasca	10.6	109	inactive
South of Lake Athabasca	11.3	225[1]	active
Northwest Territories	1.0	34[2]	inactive
Total	**204.8**	**1 570**	

Notes:
1. The total area under management is 225 hectares. Not all of this area is currently used for tailings disposal.
2. Estimated value.
Source:
Helen Griffiths, Department of Natural Resources Canada, personal communication.

1. The nuclear fuel cycle includes uranium refining and conversion, nuclear fuel fabrication and nuclear electric reactor operation.

Table 6.1.4
Inventory and Accumulation Rate of Low-level Radioactive Wastes by Source, 1991-1993

Source	Inventory 1991	Inventory 1992	Inventory 1993	Projected 2025	Accumulation rate 1993
	m^3				m^3 per year
Nuclear fuel cycle	38 540	43 530	49 300	108 500	2 720
R & D/radioisotope production	86 680	106 200	112 030	185 100	2 160
Non-nuclear activities[1]	7 930	7 920	7 640	7 600	.
Historical activities	1 163 820	1 202 340	1 264 500	1 270 900	- -
Decommissioning	1 820	2 890	3 210	190 300	280[2]
Total	**1 298 790**	**1 362 880**	**1 436 680**	**1 762 400**	**4 880**

Notes:
1. Non-nuclear activities are not directly related to the processing of radioactive materials, but they nevertheless produce low-level radioactive wastes. The combustion of coal and mineral processing are two examples.
2. The current accumulation rate does not include wastes from the decommissioning of nuclear reactors used for commercial electrical production, since no decommissioning of these units is underway. Decommissioning of commercial nuclear reactors is expected to commence after 2010; this accounts for most of the projected 2025 inventory of LLRW from decommissioning activities.
Source:
Low-level Radioactive Waste Management Office, 1995, *Inventory of Low-level Radioactive Waste in Canada: Annual Report 1993*, Ottawa.

The majority of both the current and projected inventories of post-mining/milling LLRW is contaminated soil from historical activities (Table 6.1.4).[2] However, the current accumulation rate of LLRW from historical activities—the rate at which new sites contaminated from historical activities are expected to be found—is very low. Therefore, over the period 1993 to 2025, the share of historical wastes in the inventory is projected to fall from 88% to 72%.

The inventory of post-mining/milling LLRW grew by 11% between 1991 and 1993. Its projected growth is a further 23% by 2025. The majority of this increase will be due to waste from the nuclear fuel cycle and decommissioning of nuclear electric power stations. Between 1993 and 2025, the share of stored LLRW from the nuclear fuel cycle is expected to rise from 3% to 6% of the total inventory, while that from decommissioning is expected to rise from nearly zero to 11%.

6.1.2 Greenhouse gas emissions

Total greenhouse gas (GHG) emissions increased by 11.6% between 1990 and 1996 (Table 6.1.5). Large increases were associated with mining (69.9%), fugitive emissions from crude oil and natural gas (41.7%), light-duty gasoline trucks (35.8%) and heavy-duty diesel trucks (31.2%).[3] Emissions from transportation and from residential, commercial and institutional fuel combustion increased more than the average, whereas fuel combustion

2. Historical wastes are those that have been generated by producers no longer operating or who otherwise cannot be held responsible for the management of the wastes.
3. Larger increases occurred in other categories that are relatively minor contributors to total emissions.

Table 6.1.5

Greenhouse Gas Emissions Summary, 1990 and 1996

Source	Carbon dioxide (CO_2)		Methane (CH_4)		Nitrous oxide (N_2O)		CO_2-equivalents[1]		
	1990	1996	1990	1996	1990	1996	1990	1996	Change 1990-1996
	kilotonnes								percent
Fossil fuel combustion									
Fossil fuel industries	38 500	39 800	0.7	0.7	0.4	0.4	38 600	39 900	3.4
Electricity and steam generation	94 500	100 000	0.9	0.9	2.3	2.6	95 200	101 000	6.1
Mining	7 600	12 900	0.2	0.3	0.1	0.3	7 650	13 000	69.9
Manufacturing	53 900	52 800	1.5	1.6	1.5	1.5	54 400	53 300	-2.0
Construction	728	1 120	--	--	--	--	730	1 120	53.4
Transportation									
Gasoline cars	51 600	47 300	9.0	6.9	6.4	8.4	53 800	50 100	-6.9
Light-duty gasoline trucks	20 400	26 900	4.0	4.5	4.2	8.5	21 800	29 600	35.8
Heavy-duty gasoline trucks	3 020	4 770	0.4	0.7	0.4	0.7	3 170	4 990	57.4
Motorcycles	225	206	0.2	0.2	--	--	230	210	-8.7
Off-road gasoline vehicles	4 910	4 540	6.2	5.8	0.1	0.1	5 080	4 690	-7.7
Diesel cars	657	596	--	--	--	--	664	604	-9.0
Light-duty diesel trucks	591	463	--	--	--	--	598	469	-21.6
Heavy-duty diesel trucks	24 300	32 000	1.2	1.6	0.9	1.2	24 700	32 400	31.2
Off-road diesel vehicles	10 300	13 400	0.5	0.7	4.2	5.4	11 600	15 100	30.2
Propane and natural gas vehicles	1 690	2 470	2.2	5.5	--	--	1 730	2 590	49.7
Domestic air transport	10 300	11 600	0.7	0.6	1.0	1.1	10 600	12 000	13.2
Domestic shipping	5 720	5 210	0.4	0.4	1.1	1.1	6 070	5 560	-8.4
Rail	6 310	5 580	0.4	0.3	2.5	2.3	7 110	6 290	-11.5
Pipelines	6 670	12 100	0.2	0.3	0.1	0.1	6 690	12 100	80.9
Residential	40 700	46 900	230.0	260.0	2.9	3.3	46 500	53 300	14.6
Commercial and institutional	26 000	30 100	0.5	0.6	0.3	0.3	26 100	30 200	15.7
Other	3 130	2 860	--	--	0.1	--	3 150	2 860	-9.2
Fugitive emissions - fossil fuels[2]									
Coal mining	-	-	91.0	84.0	-	-	1 900	1 800	-5.3
Crude oil and natural gas	9 800	13 000	1 200.0	1 800.0	-	-	36 000	51 000	41.7
Industrial processes									
Non-metallic mineral production	8 160	7 840	-	-	-	-	8 160	7 840	-3.9
Ammonia, adipic acid and nitric acid production	3 130	4 130	-	-	37.0	40.0	15 000	16 000	6.7
Ferrous metal production	7 590	8 290	-	-	-	-	7 590	8 290	9.2
Aluminum and magnesium production	2 640	3 730	-	-	-	-	11 000[3]	11 000[4]	-
Other and undifferentiated production	10 000	15 000	-	-	-	-	10 000	15 000	50.0
Solvent and other product use	-	-	-	-	1.4	1.5	400	900	125.0
Agriculture									
Enteric fermentation[5]	-	-	760.0	860.0	-	-	16 000	18 000	12.5
Manure management	-	-	190.0	210.0	13.0	15.0	7 900	8 900	12.7
Agricultural soils	7 000	2 000	-	-	100.0	100.0	40 000	40 000	-
Land use change and forestry[6]	-	-	70.0	40.0	4.0	3.0	2 500	1 700	-32.0
Waste									
Solid waste disposal on land	-	-	880.0	970.0	-	-	19 000	20 000	5.3
Wastewater handling	-	-	17.0	18.0	2.8	3.0	1 200	1 300	8.3
Waste incineration	250	270	0.4	0.3	0.2	0.2	320	340	6.3
Grand total	**461 000**	**508 000**	**3 500.0**	**4 300.0**	**180.0**	**210.0**	**601 000**	**671 000**	**11.6**

Notes:

Figures may not add up to totals due to rounding or because of varying degrees of uncertainty in individual estimates.

1. CO_2-equivalent emissions are the weighted sum of all greenhouse gas emissions. The following global warming potentials are used as the weights: CO_2 = 1; CH_4 = 21; N_2O = 310; HFCs = 140-11 700; PFCs = 6 500-9 200; SF_6 = 23 900.
2. Includes intentional and unintentional emissions from production, processing, transmission, storage and use of fuels, including those from flaring of natural gas at oil and gas production facilities.
3. 1990 CO_2-equivalent emissions for this industry include 6 000 kilotonnes of PFC emissions and 2 900 kilotonnes of SF_6 emissions.
4. 1996 CO_2-equivalent emissions for this industry include 6 000 kilotonnes of PFC emissions and 1 400 kilotonnes of SF_6 emissions.
5. Emissions from livestock digestive processes.
6. Only CH_4 and N_2O emissions from prescribed forest fires and other fires are included for this source. The net flux of CO_2 from forests (which was estimated to be -40 000 kilotonnes in 1990 and -30 000 kilotonnes in 1996) is not included in the total because these emissions would, to a large extent, occur in the absence of human intervention.

Source:

Environment Canada, Pollution Data Branch.

emissions from manufacturing declined during the period. Over 25% of the total increase was due to vehicle use, while another 21% came from fugitive emissions from fossil fuels.

Fossil fuel-related emissions (combustion and fugitive combined) accounted for 78% of total emissions in 1996. Among the non-fossil fuel sources, the largest contributor was agriculture. The manufacturing sector also produced considerable amounts from industrial processes such as cement production and from the smelting and refining of metal ores.

In total, the manufacturing sector accounted for 16.7% of all GHG emissions.[1] The combined fossil fuel and non-fossil fuel emissions from the manufacturing sector increased by only 5.4% between 1990 and 1996, reflecting the fact that energy efficiency gains largely offset the requirements of increased production. It should be noted that 1990 was the beginning of a recession. Thus, a portion of growth in manufacturing emissions can be explained by so-called business cycle effects. That is, 1990 emissions were lower than they would have been had the economy not been at a low point in the business cycle. This makes the gap in emissions between 1990 and 1996 greater than it might have been otherwise.

Business cycle effects are also evident in the large increase in emissions from truck transportation between 1990 and 1996. In the case of light-duty gasoline trucks, a portion of the increase is also attributable to changing consumer preferences for less fuel-efficient family vans and sport-

1. This percentage excludes the emissions resulting from transportation that manufacturing industries undertake on their own account as well as purchase from transportation companies.

Table 6.1.6
Greenhouse Gas Emissions Summary by Province and Territory, 1996

	Nfld.	P.E.I.	N.S.	N.B.	Que.	Ont.	Man.	Sask.	Alta.	B.C.	Y.T. and N.W.T.	Canada
	kilotonnes of CO_2-equivalent emissions[1]											
Fossil fuel combustion												
Fossil fuel industries	1 070	2	659	1 030	3 010	6 370	-	2 210	21 500	3 700	67	39 900
Electricity and steam generation	1 150	28	7 280	6 230	260	21 300	409	13 700	48 900	1 280	343	101 000
Mining	853	1	12	175	910	685	43	1 380	8 760	149	31	13 000
Manufacturing	271	70	776	1 450	12 000	21 900	931	2 310	8 180	7 090	25	53 300
Construction	15	7	31	43	190	191	137	88	216	203	4	1 120
Transportation	3 200	786	5 200	4 890	31 000	56 000	8 120	11 800	28 700	25 500	1 350	177 000
Residential	780	334	2 000	1 010	8 800	22 300	1 680	2 450	8 700	5 090	222	53 300
Commercial and institutional	290	172	786	462	5 000	11 300	1 660	1 450	5 250	3 380	436	30 200
Other	76	47	228	111	220	1 080	120	382	406	195	6	2 870
Fugitive emissions - fossil fuels[2]	-	-	830	1	400	1 500	490	9 600	34 000	5 800	90	53 000
Industrial processes	82	3	310	160	11 000	29 000	160	1 100	13 000	2 400	66	59 000
Agriculture	75	440	600	480	7 900	11 000	7 900	12 000	21 000	2 700	-	64 000
Waste	410	86	650	570	5 900	7 700	550	580	990	4 600	25	22 000
Other[3]	38	9	29	301	270	350	137	145	612	109	49	2 600
Grand total	**8 360**	**1 990**	**19 400**	**16 800**	**87 000**	**191 000**	**22 300**	**59 300**	**199 000**	**62 400**	**2 740**	**671 000**

Notes:
Figures may not add to totals due to rounding.
1. CO_2-equivalent emissions are the weighted sum of all greenhouse gas emissions. The following global warming potentials are used as the weights: CO_2 = 1; CH_4 = 21; N_2O = 310; HFC = 140-11 700; PFC = 6 500-9 200; SF_6 = 23 900.
2. Includes intentional and unintentional emissions from production, processing, transmission, storage and use of fuels, including those from flaring of natural gas at oil and gas production facilities.
3. Includes emissions from use of solvents, from land use change and from forestry.
Source:
Environment Canada, Pollution Data Branch.

Table 6.1.7
Pulp and Paper Mill Discharges and Compliance Performance by Pollutant and Region, 1996

Region	Mills[1]	Total suspended solids (TSS): Annual average discharge	TSS: Share of tests within allowable limits: Daily	TSS: Share of tests within allowable limits: Monthly	Biochemical oxygen demand (BOD_5): Annual average discharge	BOD_5: Share of tests within allowable limits: Daily	BOD_5: Share of tests within allowable limits: Monthly	Acute lethality: Share of tests within allowable limits: Monthly[2]
	number	kilograms per tonne	percent		kilograms per tonne	percent		
Atlantic	20	7	99.1	97.1	6.3	91.3	88.8	77.5
Quebec	46	3	99.8	99.6	2.3	98.6	98.0	80.7
Ontario	25	3	100.0	100.0	2.1	99.9	99.7	91.2
Prairies and Northern	10	3	100.0	100.0	1.2	100.0	100.0	99.2
Pacific and Yukon	23	6	99.4	97.8	2.3	99.3	99.3	97.5
Canada	**124**	**4**	**99.7**	**99.0**	**2.8**	**97.9**	**97.2**	**86.9**

Notes:
1. Includes only those mills discharging effluent directly into the environment. Thirty mills discharge to off-site facilities and six have zero effluent.
2. Mills must test their effluent for acute lethality at least monthly. In the event of a failed monthly test, weekly tests must be performed until three consecutive tests show no acute lethality.
Source:
Environment Canada, National Office of Pollution Prevention.

utility vehicles rather than automobiles. (GHG emissions from gasoline automobiles declined by 6.9% during the same period.)

Greenhouse gas emissions by province for 1996 are presented in Table 6.1.6.

6.1.3 Pulp and paper mill effluents

On May 7, 1992, the federal government passed revised *Pulp and Paper Effluent Regulations* under the *Fisheries Act*. These regulations replaced the earlier set of *Pulp and Paper Effluent Regulations* passed on November 2, 1971.

The limits for effluent discharge established in the 1992 regulations are binding on all mills that release effluent directly into the environment; mills that send their effluent to municipal wastewater treatment facilities are exempt. The regulations set limits for the release of five-day biochemical oxygen demand (BOD_5) and total suspended solids (TSS). As well, the regulations retained the earlier ban on the discharge of effluents that are acutely lethal to rainbow trout.

Effluent data for 1996 show that monthly compliance with the ban on releasing acutely lethal effluents (87%) is lower than that for the TSS (99%) and BOD_5 (97%) limits (Table 6.1.7). Environment Canada has observed that, in general, the mills that frequently released acutely lethal effluents were those with less experience operating their pollution control facilities. This may explain the lower compliance rates in the Atlantic provinces and Quebec, where a number of mills have only recently installed treatment facilities.

In addition to the above regulations, the *Pulp and Paper Mill Effluent Chlorinated Dioxins and Furans Regulations* were declared under the *Canadian Environmental Protection Act* on May 7, 1992. These regulations require mills that bleach pulp using chlorine or chlorine dioxide to prevent the formation of dioxins and furans in their processes. The regulations require measurements to be taken using specified analytical techniques at regular intervals.

By 1995, annual discharges of dioxins and furans from pulp and paper mills were 99% lower than the level prior to the 1992 regulations. The following section presents more complete information on the releases of dioxins and furans.

6.1.4 Releases of dioxins and furans

Dioxins and furans are the common names of polychlorinated dibenzo-*p*-dioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs) (see section 6.5–**Contaminants in biota** for further information). These substances enter the environment from a number of sources, including waste incineration, pulp and paper manufacturing, and treated wood products.

The Toxic Substances Management Policy (TSMP) adopted by the federal government in 1995 established the goal of virtual elimination of toxic substances that result from human activity and meet specific criteria for persistence and bioaccumulation. PCDDs and PCDFs have

Table 6.1.8
Dioxin and Furan Releases by Medium and Source, 1990, 1997 and 1999

Medium/Source	1990	1997	1999[1]
	grams TEQ per year[2]		
Releases to air			
Municipal waste incineration	204.8	151.7	82.2
Residential wood combustion	35.7	35.7	35.7
Iron manufacturing, sintering plants	42.9	42.9	23.5
Pulp and paper manufacturing, combustion of salt-laden wood	10.5	10.5	10.5
Steel manufacturing, electric arc furnaces	9.1	10.2	10.2
Diesel fuel combustion (transport)	8.7	8.7	8.7
Residential heating oil combustion	7.0	7.0	7.0
Electric power generation	3.4	4.6	4.6
Wood waste combustion	4.4	4.4	4.4
Cement kilns	2.6	2.8	2.8
Hospital incinerators	8.3	2.5	2.5
Chemical manufacturing	2.2	2.0	0.4
Utility poles (in use)	1.9	1.9	1.9
Wood preserving plants	1.8	1.8	1.8
Hazardous waste incinerators	2.1	1.3	0.8
Pulp and paper manufacturing, kraft liquor boilers	0.7	0.7	0.7
Federally owned incinerators (all types)	1.3	0.6	0.6
Steel foundries, electric arc furnaces	0.4	0.5	0.5
Sewage sludge incinerators	0.3	0.3	0.3
Base metal smelting	0.1	0.1	0.1
Secondary lead smelters	0.1	0.1	0.1
Biomedical waste incinerators	4.9	-	-
Petroleum refineries	..	..	..
Subtotal, releases to air	**353.2**	**290.3**	**199.3**
Releases to water			
Pulp and paper manufacturing	450.0	5.0	5.0
Wastewater treatment systems	..	..	..
Chemical production	3.7	-	-
Subtotal, releases to water	**453.7**	**5.0**	**5.0**
Releases to soil			
Pesticides	..	..	..
Sewage sludge	..	..	..
Utility poles (in use)	9.0	9.0	9.0
Railroad ties (in use)	164.0	164.0	164.0
Pulp and paper manufacturing, ash from salt-laden wood[3]	137.0	137.0	137.0
Out-of-service utility poles and railway ties (landfilled)[3]	88.5	88.5	88.5
Subtotal, releases to soil	**173.0**	**173.0**	**173.0**
Grand total	**979.9**	**468.3**	**377.3**

Notes:
Figures may not add up to totals due to rounding.
1. Projection.
2. Grams of toxic equivalents per year. The reference for toxicity is 2,3,7,8 TCDD, which is the most toxic form of dioxin.
3. If these products are properly disposed of in a controlled landfill site, their releases do not necessarily enter the soil. The figures reported in this table, therefore, represent an upper limit on the quantity of dioxins and furans that might enter the soil from these sources. For this reason, the figures have not been included in the subtotal for releases to soil.
Source:
Environment Canada, 1999, Dioxins and Furans and Hexachlorobenzene: Inventory of Releases.

been found to meet these criteria and have been slated for virtual elimination from the environment under the TSMP.

As illustrated in Table 6.1.8, total releases of dioxins and furans declined by over 52% between 1990 and 1997. This was largely due to the 99% drop in water-borne releases from pulp and paper manufacturing. As noted above, this dramatic decline was due to the introduction of regulations under the *Canadian Environmental Protection Act*.

With the virtual elimination of water-borne dioxin and furan releases from the pulp and paper industry already achieved by 1997, total releases were projected to decline less dramatically (19%) between 1997 and 1999. Most of this decline was expected to come from two sources: municipal waste incineration and iron sintering plants. The reduction in releases from municipal waste incineration was expected to result from upgrading of pollution control equipment at the municipal incinerator in Lévis, Quebec. In the case of iron sintering, closure of the Algoma Steel plant in Wawa, Ontario was the expected source of the reduction.

6.1.5 Disposal at sea

Environment Canada issues permits for the disposal at sea of excavated earth, material dredged from waterways, fish processing waste, retired vessels and 'other' wastes. Each permit is subject to a technical review and public notice. No permit is issued if practical alternatives to disposal at sea are available.

In the past, the actual quantity of wastes disposed of at sea was typically lower than that permitted for disposal. Companies applying for permits, particularly those operating dredging operations, often overestimated their needs to ensure compliance with the terms of their permits. As of March 17, 1999 a new fee of \$470 per thousand m^3 came into effect for wastes disposed of at sea. It was expected that this would provide an incentive to companies to reduce the wastes they dispose of at sea and to seek only those permits they actually require.[1]

Between 1987 and 1997, nearly 1 800 permits for disposal at sea were issued in Canada (Table 6.1.9). Of the wastes actually disposed of, more than 98% were from dredging and excavation activities. Although approximately 65% of all permits were issued in Atlantic Canada, this region accounted for only 29% of the waste permitted for dumping. Most of the permits issued in the Atlantic region were for fish waste.

6.1.6 Municipal wastewater

Municipal wastewater treatment facilities provide one of three levels of treatment:

- *primary* treatment removes insoluble matter only;
- *secondary* treatment removes biological impurities from water treated at the primary level; and
- *tertiary* treatment removes nutrients and chemical contaminants remaining after secondary treatment.

The quality of the treated wastewater returned to the environment is dependent on the level of treatment received.

Wastewater treatment levels vary considerably across Canada. Map 6.1.1 shows the level of treatment by sub-drainage basin in 1983 and 1996. Drainage basins are particularly useful for presenting these data, since all waste-water released within a given basin ultimately ends up in the

1. P. Topping, Environment Canada, personal communication.

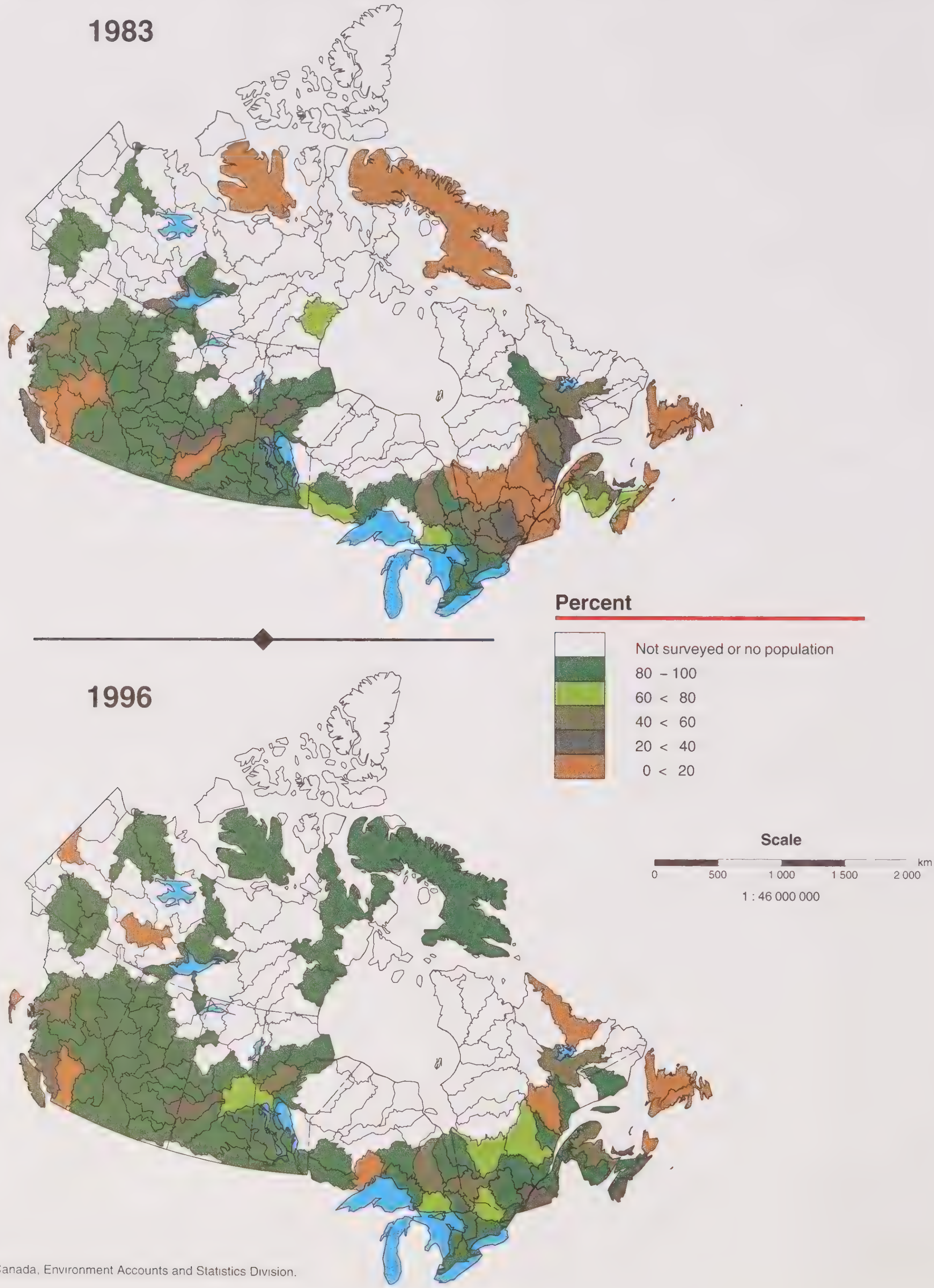
Table 6.1.9
Disposal at Sea: Permits Issued and Quantities Permitted, 1987-1997

Year	Dredging		Excavation		Fish waste		Vessels and other[1]		Total	
	Quantities permitted	Permits issued	Quantities permitted	Permits issued	Quantities permitted	Permits issued	Quantities permitted	Permits issued	Quantities permitted	Permits issued
	thousand tonnes	number	thousand tonnes	number	thousand tonnes	number	thousand tonnes	number	thousand tonnes	number
1987	6 900	122	95	2	225	27	60	14	7 281	165
1988	7 500	127	632	5	152	16	2	11	8 286	159
1989	6 600	109	865	5	130	48	10	15	7 605	177
1990	6 200	77	2 375	9	165	102	3	12	8 743	200
1991	5 600	88	1 157	4	143	124	1	7	6 902	223
1992	6 500	83	489	3	99	121	6	12	7 094	219
1993	6 400	76	666	3	77	107	5	9	7 149	195
1994	6 600	62	650	2	78	83	3	2	7 331	149
1995	6 000	51	1 638	5	50	46	3	3	7 691	105
1996	5 500	46	1 690	4	40	44	3	4	7 233	98
1997	5 200	45	1 365	5	52	40	2	1	6 619	91

Note:
1. Includes vessels, scrap metal and 'other' materials. The 'other' materials are not included in the measure of quantities permitted for disposal, as some of these permits were issued by number of pieces and not by weight.
Source:
Environment Canada, 1998, *A Summary of Permits Issued Under the Canadian Environmental Protection Act in 1997: Report to the London Convention 1998*, Ottawa.

Map 6.1.1

Population Served by Secondary or Better Wastewater Treatment by Sub-drainage Basin, 1983 and 1996



Source:
Statistics Canada, Environment Accounts and Statistics Division.

same river system. (For more information on drainage basins, see section 3.1–**Environmental geographies.**)

As shown in Map 6.1.1, people living in Ontario and the Prairie provinces tend to receive a higher level of wastewater treatment than those living in the rest of the country. Population served by wastewater treatment increased between 1983 and 1996. Significant improvements were made in Quebec and the far north during this period.

Table 6.1.10 shows that 6% of the population served with sewers[1] across the country in 1996 actually received no wastewater treatment; their wastewater was released straight into a receiving water body. Here again, significant regional differences were evident. Fully 46% of the population served by sewers in the Atlantic provinces received no wastewater treatment. In contrast, all those served by sewers in Ontario and the Prairie provinces received at least primary treatment. In fact, the majority of the population served by sewers in Ontario and the Prairie provinces received tertiary treatment for their wastewater. No other region of the country came close to matching this level.

Table 6.1.11 shows how the level of wastewater treatment across the country changed between 1983 and 1996. As can be seen, 72% of those Canadians served with sewers in 1983 received some level of wastewater treatment. By 1996, this figure had climbed to 94%. Encouragingly, much of the growth in treatment during this period was in tertiary treatment. Only 28% of people served by sewers in 1983 received tertiary treatment; in 1996, 41% received this treatment level. Thus, not only did more people receive wastewater treatment in 1996 than in 1983, but the quality of the treatment they received was substantially better.

1. Includes those served by municipal septic trucks.

Table 6.1.10
Municipal Wastewater Treatment by Level and Region, 1996

Region	Population with sewers[2]	Treatment level[1]: None		Primary		Waste stabilization pond[3]		Secondary		Tertiary		Average daily flow of treated sewage	Share of total
	persons	persons	percent	persons	percent	persons	percent	persons	percent	persons	percent	m^3	percent
Atlantic provinces	1 291 925	595 143	46	193 040	15	150 568	12	348 722	27	4 452	--	428 011	3
Quebec	5 495 535	644 809	12	2 291 735	42	789 073	14	1 381 013	25	388 906	7	4 896 120	35
Ontario	8 708 844	4 217	--	508 335	6	195 288	2	1 397 798	16	6 603 207	76	5 223 557	38
Prairie provinces	3 637 882	100	--	57 876	2	482 400	13	1 181 820	32	1 915 686	53	1 667 691	12
British Columbia	2 902 693	61 980	2	1 897 677	65	174 571	6	540 227	19	228 237	8	1 683 776	12
Territories	70 891	1 700	2	3 063	4	66 128	93	-	-	-	-	30 198	--
Canada	**22 107 770**	**1 307 949**	**6**	**4 951 725**	**22**	**1 858 028**	**8**	**4 849 580**	**22**	**9 140 488**	**41**	**13 929 353**	**100**

Notes:
1. Although a small percentage of the rural population is reported to receive municipal wastewater treatment in the Municipal Water Use Database, the database does not provide information on the level of treatment received by these rural dwellers. For the purposes of this table, the rural populations receiving wastewater treatment in each province have been distributed among the four treatment levels by assuming that rural dwellers receive the same level of treatment as their urban neighbours. That is, the share of urban residents covered by each level of treatment was applied to that segment of the rural population that reported receiving municipal wastewater treatment.
2. Includes those served by municipal septic trucks.
3. Waste stabilization ponds, or sewage lagoons, are simple wastewater treatment systems capable of delivering treatment equivalent to that of a secondary wastewater treatment facility.
Source:
Environment Canada, Municipal Water Use Database.

Table 6.1.11
Municipal Wastewater Treatment Level for Population Served with Sewers,[1] Various Years

Treatment level[2]	1983[3]		1986[3]		1989[3]		1991		1994		1996	
	persons	percent	persons	percent	persons	percent	persons	percent	persons	percent	persons	percent
None	5 174 430	28	5 192 590	28	3 762 244	19	2 992 225	15	1 570 424	7	1 307 949	6
Primary	2 897 952	16	2 814 707	15	3 950 312	20	4 196 728	20	4 921 710	23	4 951 725	22
Waste stabilization pond[4]	1 122 353	6	1 117 996	6	1 335 835	7	1 395 948	7	1 624 082	8	1 858 028	8
Secondary	3 995 769	22	3 756 664	20	4 208 962	22	4 415 703	22	4 918 990	23	4 849 580	22
Tertiary	5 046 070	28	5 819 450	31	6 245 464	32	7 535 094	37	8 207 684	39	9 140 488	41
Total	**18 236 574**	**100**	**18 701 407**	**100**	**19 502 817**	**100**	**20 535 698**	**100**	**21 242 890**	**100**	**22 107 770**	**100**

Notes:
1. Includes those served by municipal septic trucks.
2. Although a small percentage of the rural population is reported to receive municipal wastewater treatment in the Municipal Water Use Database, the database does not provide information on the level of treatment received by these rural dwellers. For the purposes of this table, the rural populations receiving wastewater treatment in each province have been distributed among the four treatment levels by assuming that rural dwellers receive the same level of treatment as their urban neighbours. That is, the share of urban residents covered by each level of treatment was applied to that segment of the rural population that reported receiving municipal wastewater treatment.
3. The data for 1983, 1986 and 1989 do not include the population in rural areas served by municipal wastewater systems, whereas those for later years do. Since only a small percentage of the rural population receives municipal wastewater treatment, its exclusion in the earlier years does not seriously affect the comparability of the time series.
4. Waste stabilization ponds, or sewage lagoons, are simple wastewater treatment systems capable of delivering treatment equivalent to that of a secondary wastewater treatment facility.
Source:
Environment Canada, Municipal Water Use Database.

Table 6.1.12
Disposal of Waste[1] by Province and Territory, 1994 and 1996

Province/Territory	Total disposal 1994	Total disposal 1996	Disposal per capita 1994	Disposal per capita 1996
	tonnes			
Newfoundland	486 523	409 350	0.84	0.67
Prince Edward Island	x	x	x	x
Nova Scotia	713 941	553 638	0.76	0.59
New Brunswick	576 102[2]	505 957	0.76	0.67
Quebec	5 189 400[2]	5 491 000[2]	0.71	0.75
Ontario	7 350 586	6 915 149	0.67	0.62
Manitoba	951 142	947 884	0.84	0.84
Saskatchewan	925 121	900 447	0.91	0.88
Alberta	2 329 327	2 393 855	0.86	0.88
British Columbia	2 791 478[2]	2 432 622	0.76	0.62
Yukon Territory	x	x	x	x
Northwest Territories	x	x	x	x
Canada	**21 464 714**	**20 598 088**	**0.73**	**0.69**

Notes:
1. Total amount of waste disposed of in public and private waste disposal facilities. Does not include wastes disposed of in hazardous waste disposal facilities or wastes managed by the waste generator on site.
2. Figure derived from the results of complementary surveys conducted by the province.
Source:
Statistics Canada, Environment Accounts and Statistics Division.

6.1.7 Solid wastes

In 1996, the waste management industry in Canada disposed of approximately 20.6 million tonnes of non-hazardous solid waste (Table 6.1.12).[1] This represented a decline from the 1994 quantity of 21.5 million tonnes.

1. Statistics Canada, 1998, *Waste Management Industry Survey: Government Sector, 1994*, Catalogue No. 16F0002XPE, Ottawa.

Disposal per capita in 1996 amounted to approximately 0.69 tonnes per person. This was also a decline from the 1994 figure of 0.73 tonnes per person.

In addition to non-hazardous wastes, the waste management industry handled 1.8 million tonnes of materials for recycling or reuse in 1995 (Table 6.1.13).

Waste management companies in Ontario handled the majority of waste prepared for recycling or reuse (52%). Firms operating in Quebec (21%) and British Columbia (15%) also handled substantial shares.

6.1.8 Spill events

Occasionally, harmful substances are accidentally released into the environment. As a result, otherwise useful products become wastes and/or existing wastes are released in a way that is more harmful to the environment than proper disposal. Environment Canada, in co-operation with other agencies, tracks the occurrences of these spills.[2]

Environment Canada noted that during the period 1984 to 1995, the top five spill causes were equipment failure, human error, corrosion, material failure, and storm or flood. The largest spills were consistently of sewage or another liquid effluent (89% of total quantity reported), often as the result of a storm or flood.

2. Environment Canada, 1998, *Summary of Spill Events in Canada, 1984–1995*, Catalogue No. En49-14/5-3E, Ottawa.

Table 6.1.13
Materials Prepared for Recycling or Reuse by Type,[1] 1995

	Newsprint and fine paper	Corrugated cardboard	Ferrous and non-ferrous metals[2]	Glass	Aluminum	Wood	Plastic	Oils and solvents	Other materials[3]	Total
					tonnes					
Province/Territory										
Newfoundland	x	x	x	x	x	x	x	x	x	37 996
Prince Edward Island	x	x	x	x	x	x	x	x	x	x
Nova Scotia	12 527	5 538	2 160	2 663	839	1 055	1 215	506	5 273	31 776
New Brunswick	x	x	x	230	x	x	818	x	11 378	25 830
Quebec	130 397	90 569	23 097	10 614	28 667	7 539	15 430	2 782	68 026	377 122
Ontario	228 390	217 704	42 868	51 167	20 787	29 189	35 036	63 356	259 437	947 934
Manitoba	x	x	x	x	x	x	x	x	x	20 596
Saskatchewan	x	x	x	x	x	x	x	x	x	x
Alberta	28 921	11 384	4 120	7 382	2 475	1 939	1 747	5 936	15 556	79 460
British Columbia	33 908	28 891	6 429	22 062	4 271	50 505	x	x	86 655	274 380
Yukon and Northwest Territories	x	x	x	x	x	x	x	x	x	x
Employment size group										
Under 20 employees	20 045	28 164	5 221	21 410	11 465	44 083	47 992	9 722	241 155	429 257
20 to 49 employees	107 855	44 303	12 644	25 584	24 045	4 049	9 576	24 079	21 965	274 100
50 and more employees	327 846	313 348	65 206	50 038	22 503	49 274	37 391	59 067	189 523	1 114 197
Canada[4]	**455 746**	**385 815**	**83 071**	**97 032**	**58 013**	**97 406**	**94 959**	**92 868**	**452 643**	**1 817 554**

Notes:
Figures may not add up to totals due to rounding.
1. This information covers only those companies that were surveyed and reported material preparation activities. Excluded are wholesale trade companies whose principal source of income is scrap material wholesaling. These industries are not considered part of the waste management industry for the purposes of the Waste Management Industry Survey.
2. Except aluminum.
3. Includes tires, textiles and contaminated soils.
4. As companies may operate in more than one province, the national totals will not equal the sum of the provincial totals.
Source:
Statistics Canada, 1998, *Waste Management Industry Survey: Business Sector, 1995*, Catalogue No. 16F0003XPE, Ottawa.

Table 6.1.14
Five Most Frequently Spilled MIACC List 1 Substances,[1] 1984-1995

Year	Anhydrous ammonia	Chlorine	Gasoline	Hydrochloric acid	Propane
	tonnes				
1984	27	3	5 632	36	19
1985	25	--	1 746	57	1 591
1986	33	409	909	53	25
1987	7	--	837	189	1
1988	17	9	1 096	51	1
1989	27	1	746	250	11
1990	86	--	675	106	64
1991	4	--	508	55	137
1992	28	1	6 439	346	15
1993	70	--	689	37	57
1994	13	8	206	72	43
1995	18	16	247	25	2
Total	**355**	**447**	**19 730**	**1 277**	**1 966**

Note:
1. The Major Industrial Accidents Council of Canada (MIACC) List 1 is a list of high priority, highly hazardous substances that have a history of spill events. The top substances were involved in the highest number of spills.
Source:
Environment Canada, 1998, *Summary of Spill Events in Canada, 1984-1995*, Report No. En49-14/5-3E, Ottawa.

The Major Industrial Accidents Council of Canada (MIACC) is a non-profit organization that attempts to limit the frequency and severity of major industrial accidents involving hazardous substances. It has prepared a short list of substances that are commonly found in Canada, are highly hazardous to people or the environment if spilled, and have a history of spill events. Table 6.1.14 presents the 'List 1' substances involved in the highest number of spills between 1984 and 1995.

6.1.9 National Pollutant Release Inventory

In 1993, the National Pollutant Release Inventory (NPRI) was established by Environment Canada to monitor the release of pollutants by facilities in Canadian communities. Table 6.1.15 shows the 1996 quantities of the most common pollutants released on-site to air, water, land and underground injection. Air was the most common release medium, receiving 68.6% of the total weight of pollutants released.[1]

Ammonia and methanol are by far the most common industrial pollutants released in Canada. Of the many industries that release these pollutants, the most notable are the chemical, pulp and paper, and fossil fuel extraction and refining industries. Xylene and toluene are found in aviation fuel and, along with acetone and methyl ethyl ketone, in thinners and solvents released by numerous industries. Zinc and sulphuric acid are released mainly by primary metal industries; hydrochloric acid is a by-product of the industrial and heavy construction industries; and ethylene glycol, a common antifreeze, is used heavily by the air transportation industry for de-icing purposes.

1. These figures are subject to change as the NPRI database is continually updated. The data in this report reflect a database extraction conducted on February 1, 1999.

Table 6.1.15
On-site Releases of Pollutants in Canada: Ten Most Common by Weight, 1996

Pollutant	Air	Underground	Water	Land	Total[1]
	tonnes				
Ammonia (total)[2]	18 198	7 811	5 972	80	32 065
Methanol	16 161	3 342	2 172	46	21 734
Xylene (mixed isomers)	6 521	16	2	24	6 575
Zinc and its compounds	953	--	341	4 990	6 292
Toluene	6 029	43	7	45	6 139
Sulphuric acid	5 651	-	158	--	5 815
Methyl ethyl ketone	4 441	1 100	--	2	5 552
Hydrochloric acid	4 892	136	16	--	5 050
Acetone	4 045	610	76	2	4 740
Ethylene glycol	504	384	69	3 210	4 170

Notes:
1. Total releases may be greater than the sum of releases by environmental medium, since companies could report releases of less than one tonne as a total without specifying the medium of release.
2. Refers to the total of both ammonia (NH_3) and ammonium ion (NH_4^+) in solution.
Source:
Environment Canada, Pollution Data Branch, National Pollutant Release Inventory Database, <http://www.ec.gc.ca/pdb/npri/>, (accessed February 1, 1999).

6.1.10 Criteria air contaminants

The 1995 National Emissions Inventory of Criteria Air Contaminants (Table 6.1.16) was compiled by Environment Canada and the provincial/territorial ministries of the environment and energy. The inventory contains estimates of criteria air contaminant emissions for more than 60 industrial and non-industrial activities. Criteria contaminants are those for which ambient air quality standards have been established by government: total particulate matter, sulphur oxides, nitrogen oxides, volatile organic compounds and carbon monoxide.

This latest five-yearly update to the inventory contains estimates for emissions of fine particulate matter (PM_{10} and $PM_{2.5}$) for the first time. Aside from this change, the inventory contains numerous other improvements resulting from use of the latest methods and technical information available in Canada and internationally. Estimates have been improved for on-road and off-road transportation, the upstream oil and gas industry, the mining industry, residential fuelwood combustion, road dust, construction activities, forest fires and the domestic and commercial uses of solvents. Estimates for a total of 1 100 new industrial facilities were added to the inventory, bringing the total number of facilities covered to 4 600.

Because of the significant improvements in the 1995 inventory, comparison with previous inventories is possible only in the case of sulphur oxide (SO_x) emissions. A recalculation of the 1990 inventory currently under development will eventually allow comparison of emission trends between these two years.

Table 6.1.16
Criteria Air Contaminant Emissions, 1995

Emission category/sector	Particulate matter[1] Total	PM_{10}[2]	$PM_{2.5}$[3]	SO_x[4]	NO_x[5]	VOC[6]	Carbon monoxide
	tonnes						
Industrial fuel combustion and processes							
Abrasives manufacture	784	361	254	2 827	187	1 481	519
Aluminum industry	11 758	7 787	5 331	46 236	1 058	963	297 931
Asbestos industry	80	48	25	763	240	1	23
Asphalt paving industry	32 930	5 460	1 950	2 384	2 014	3 318	1 423
Bakeries	-	-	-	-	5	6 005	-
Cement and concrete industry	21 079	8 486	3 769	33 984	32 168	438	27 995
Chemicals industry	4 495	2 611	1 391	6 430	24 118	9 403	6 708
Clay products industry	2 576	622	181	34	128	3	29
Coal mining industry	11 663	8 849	6 265	5 321	3 232	1 762	105
Ferrous foundries	667	448	362	1 673	28	1 807	3 581
Grain industries	58 274	11 729	1 742	1	31	2	6
Iron and steel industries	20 672	10 813	7 085	62 801	25 490	28 277	738 991
Iron ore mining industry	39 412	21 290	7 625	54 650	7 767	839	23 813
Mining and rock quarrying	86 016	11 508	3 223	20 770	14 578	688	3 430
Non-ferrous mining and smelting industry	15 630	13 159	9 845	891 720	3 532	75	399
Oil sands	3 937	1 787	1 407	160 948	16 542	81	1 447
Other petroleum and coal products industry	324	121	57	578	418	88	22
Paint and varnish manufacturing	124	99	35	-	18	1 957	3
Petrochemical industry	1 310	660	265	1 275	11 598	16 523	15 766
Petroleum refining	6 522	5 012	3 268	141 086	26 923	47 655	14 101
Plastics and synthetic resins fabrication	162	90	62	272	382	6 684	417
Pulp and paper industry	74 384	50 835	39 337	77 030	58 064	23 283	186 855
Upstream oil and gas industry	2 053	2 005	1 938	387 261	314 905	689 393	55 446
Wood industry	153 697	86 002	52 594	2 621	16 025	47 100	761 207
Other industries	72 623	37 477	23 835	48 953	60 902	52 995	37 052
Subtotal, industrial fuel combustion and processes	**621 171**	**287 258**	**171 849**	**1 949 617**	**620 351**	**940 821**	**2 177 266**
Non-industrial fuel combustion							
Commercial fuel combustion	3 402	3 004	2 720	13 014	29 349	1 730	6 052
Electric power generation (utilities)	78 797	34 874	18 633	534 323	254 985	2 980	25 359
Residential fuel combustion	4 829	3 996	3 730	17 270	36 699	2 311	13 915
Residential fuel wood combustion	137 840	137 268	131 797	1 837	12 176	400 092	1 033 294
Subtotal, non-industrial fuel combustion	**224 868**	**179 141**	**156 881**	**566 445**	**333 210**	**407 112**	**1 078 622**
Transportation							
Air transportation	2 018	1 115	787	2 263	34 026	11 636	61 758
Heavy-duty diesel vehicles	32 075	32 075	29 498	32 807	378 300	48 540	224 438
Heavy-duty gasoline trucks	545	528	414	588	15 073	11 814	164 787
Light-duty diesel trucks	1 304	1 304	1 203	1 535	5 567	2 600	4 626
Light-duty diesel vehicles	379	379	347	632	1 978	747	1 667
Light-duty gasoline trucks	2 586	2 509	1 986	4 399	112 437	142 425	1 461 808
Light-duty gasoline vehicles[7]	4 870	4 717	3 256	11 048	273 396	355 873	3 558 667
Marine transportation	8 438	8 129	7 379	58 000	118 578	37 449	103 310
Motorcycles	16	16	11	34	630	2 027	10 873
Off-road use of diesel	17 081	17 081	15 714	16 149	209 231	22 581	66 365
Off-road use of gasoline	4 414	3 867	3 393	1 005	25 395	93 111	1 027 393
Rail transportation	19 492	19 492	17 933	7 226	115 604	5 608	22 022
Tire wear and brake linings	4 362	4 313	1 353	-	-	-	-
Subtotal, transportation	**97 580**	**95 524**	**83 276**	**135 686**	**1 290 214**	**734 412**	**6 707 715**
Incineration							
Crematorium	3	2	1	3	19	-	8
Industrial and commercial incineration	70	51	38	603	752	690	2 573
Municipal incineration	435	370	355	457	1 298	703	1 898
Wood waste incineration	1 846	1 015	738	42	318	4 568	41 360
Other incineration and utilities	157	38	16	149	163	294	818
Subtotal, incineration	**2 510**	**1 476**	**1 149**	**1 253**	**2 550**	**6 255**	**46 656**
Miscellaneous							
Cigarette smoking	962	962	962	-	8	8	3 124
Dry cleaning	-	-	-	-	1	7 832	-
Fuel marketing	30	30	30	2	256	98 498	127
General solvent use	-	-	-	-	-	274 926	-
Marine cargo handling industry	3 074	1 385	416	-	-	1	-
Meat cooking	1 594	1 594	1 583	-	-	-	-
Pesticides and fertilizer application	10 516	5 153	1 472	-	792	66	-
Printing	-	-	-	-	-	29 058	-
Structural fires	5 297	5 244	4 768	-	10	5 147	10 988
Surface coatings	-	-	-	-	-	134 194	-
Subtotal, miscellaneous	**21 472**	**14 368**	**9 232**	**2**	**1 068**	**549 731**	**14 239**

Table 6.1.16
Criteria Air Contaminant Emissions, 1995 (continued)

Emission category/sector	Particulate matter[1] Total	PM_{10}[2]	$PM_{2.5}$[3]	SO_x[4]	NO_x[5]	VOC[6]	Carbon monoxide
	tonnes						
Open sources							
Agriculture (animals)	248 734	141 041	22 280	-	-	12 982	-
Agriculture tilling and wind erosion	1 754 440	848 408	20 664	-	-	-	-
Construction operations	2 402 115	528 449	10 707	-	-	-	-
Dust from paved roads[8]	2 549 526	511 159	129 517	-	-	-	-
Dust from unpaved roads[8]	6 833 650	2 020 663	300 644	-	-	-	-
Forest fires	835 391	706 095	585 048	478	211 027	902 444	6 772 432
Landfill sites	4 735	379	94	-	-	5 139	-
Mine tailings	46 858	3 749	937	-	-	-	-
Prescribed burning	41 415	32 986	26 872	92	5 551	16 306	330 906
Subtotal, open sources	**14 716 862**	**4 792 926**	**1 096 763**	**569**	**216 578**	**936 871**	**7 103 338**
Grand total	**15 684 465**	**5 370 694**	**1 519 149**	**2 653 571**	**2 463 971**	**3 575 202**	**17 127 836**

Notes:
Figures may not add up to totals due to rounding.
The 1995 Criteria Air Contaminants Inventory was compiled using the latest technical and statistical information and, with the exception of SO_x emissions estimates, is not comparable to earlier inventories.
1. Total particulate matter comprises solid and liquid particles released into the atmosphere with an upper size limit generally considered to be 75 micrometres in aerodynamic equivalent diameter.
2. PM_{10} is the fraction of total particulate matter that is less than or equal to 10 micrometres in aerodynamic equivalent size.
3. $PM_{2.5}$ is the fraction of total particulate matter that is less than or equal to 2.5 micrometres in aerodynamic equivalent size.
4. SO_x comprises all emissions of gaseous sulphur dioxide (SO_2). In some cases, emissions may contain small amounts of sulphur trioxide (SO_3) and sulphurous and sulphuric acid vapour.
5. NO_x comprises gaseous nitrous oxide (NO) and nitrogen dioxide (NO_2).
6. Volatile organic compounds (VOCs) comprise all photochemically reactive hydrocarbon compounds (that is, those that participate in chemical reactions when exposed to sunlight). They are major contributors to smog in urban areas.
7. The Ontario estimates include emissions from propane vehicles.
8. Work is in progress to improve the road dust emission estimates.
Source:
Environment Canada, Pollution Data Branch.

Environmental quality and human health

Monitoring the quality of the environment is an integral part of understanding the impacts of human activities. Changes in human activities are often initiated by perceived changes in the quality of the air, water, land and living resources. Science has made progress in understanding the effects of local and regional pollution on human health and the environment, but there are still a number of grey areas. Pollution at the local level can be a threat to health and well-being, particularly in large urban areas or near industrial sites. International sources of pollution are also a cause for concern.

6.2 Air quality

The world's consumption of fossil fuels—coal, oil and natural gas—has increased significantly since the beginning of the Industrial Revolution, 200 years ago. The use of fossil fuels for transportation and various industrial processes has led to significant economic growth and many technological advances. However, fossil fuel combustion has also been the leading cause of poor air quality in urban and rural areas around the world.

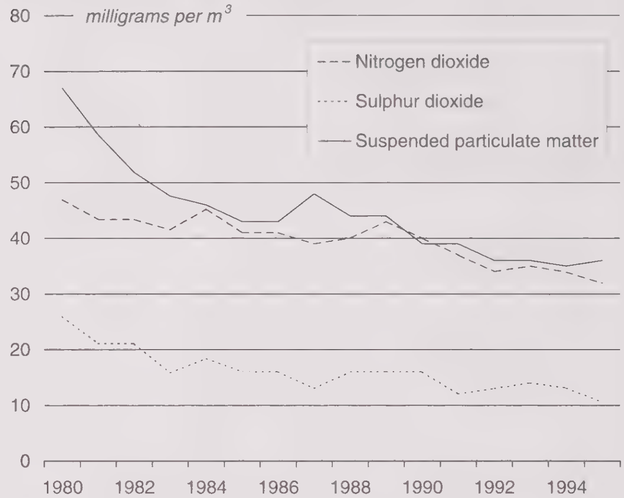
In Canada, the improvement in air quality in large cities over the last 30 years has been largely due to cleaner fuels such as unleaded gasoline, the introduction of catalytic converters on motor vehicles, and the increased use of nuclear and hydro-electric power generation.[1] Nevertheless, several Canadian cities continue to experience poor air quality, especially in summer, and this may contribute to some health problems (see section 6.6–**Human health**). Air pollution can also be harmful to food crops, fresh water resources, forests, wildlife and ecosystems in general. The physical effects of air pollution may also be seen on buildings and monuments, as well as on textiles, rubber and other materials.

6.2.1 Ambient air quality

The primary source of ambient air pollution is the burning of fossil fuels such as gasoline and diesel fuels, oil and coal.

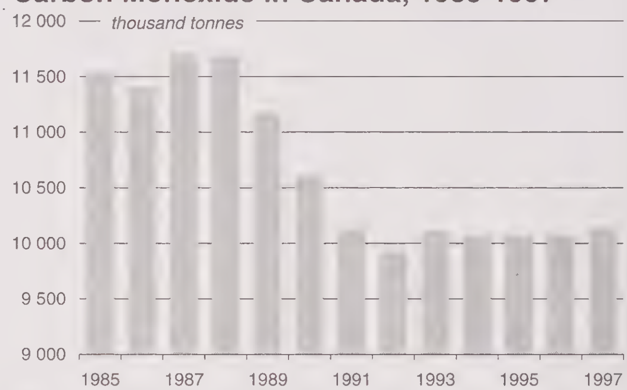
1. Environment Canada, 1999, *Urban Air Quality,* National Environmental Indicator Series, SOE Bulletin No. 99-1, Ottawa.

Figure 6.2.1
National Trends in Concentrations of Sulphur Dioxide, Nitrogen Dioxide and Suspended Particulate Matter,[1] 1980-1995



Notes:
Annual concentrations represent a composite average.
1. Particles smaller than 75 micrometers.
Source:
Environment Canada, Pollution Data Branch.

Figure 6.2.2
Total Human Activity-Sourced Emissions of Carbon Monoxide in Canada, 1985-1997



Note:
Annual emissions of carbon monoxide for the period 1991 to 1997 are preliminary forecasts only.
Source:
Environment Canada, Pollution Data Branch.

Common air pollutants

The National Air Pollution Surveillance (NAPS) network was established in 1969 to monitor air pollutants in major urban centres across Canada (figures 6.2.1 and 6.2.2). Five common air pollutants are monitored by NAPS:

- **Sulphur dioxide** (SO_2) is a colourless gas, with a strong odour like burned matches. Oil and gas processing, sulphur-rich ore smelting and the burning of coal and heavy oil contribute most of the major human-sourced SO_2.
- **Carbon monoxide** (CO) is a toxic, colourless and odourless gas, generated primarily from automobile emissions, the heating of dwellings and industrial processes.
- **Nitrogen dioxide** (NO_2) is generated through high-temperature processes, including transportation and industrial fuel combustion.
- **Ground-level ozone** (O_3) is a colourless gas with a strong smell and is the primary component of smog, a serious air pollution problem in several Canadian urban areas (Text Box 6.2.1). It should not be confused with stratospheric ozone. Ground-level ozone is a secondary pollutant produced by the chemical reaction of nitrogen oxides (NO_x) and volatile organic compounds (VOCs) in the presence of sunlight.
- **Suspended particulate matter** (PM) consists of a broad category of air pollutants that includes a range of small solids or liquids varying in size and chemical composition. Suspended particulates are either natural—for example, sea salt, dust, pollen, smoke and volcanic ash—or produced by human activities such as transportation, mining operations, thermal power generation and waste incineration.

National ambient air quality objectives (NAAQOs)

National ambient air quality objectives (NAAQOs) have been determined for five air pollutants monitored by NAPS. Three levels of NAAQOs have been defined: desirable, acceptable and tolerable. The long-term goal of NAAQOs is to meet the 'maximum desirable' objective and provide a basis for antidegradation policy for the unpolluted parts of the country. The 'maximum acceptable' objective is intended to provide adequate protection against adverse effects on human health, animals, vegetation, soil, water, materials and visibility. The 'maximum tolerable' objective defines concentrations of air contaminants where action is required to protect human health and the environment. Levels greater than the maximum tolerable objective require immediate attention to improve air quality.[1] In general, air quality in Canada has improved since 1974 (Table 6.2.1).

Text Box 6.2.1
Smog

The term 'smog' was coined more than four decades ago to describe a mixture of smoke and fog in the air. Today, smog refers to a noxious mixture of air pollutants, including vapours, gases and particles, that can often be seen as a yellowish-brown haze in the air.

The two main components of smog in Canadian air are ground-level ozone and fine airborne particles. Ozone is produced by the sun's photochemical action on volatile organic compounds (VOCs) and nitrogen oxides (NO_x). Human activity-sourced VOCs include car exhaust and vapours from gasoline pumps, oil-based paints and solvents. Forests are the main source of naturally occurring VOCs. Canada's current air quality objective for ground-level ozone is 82 parts per billion over a one-hour period (maximum acceptable concentration), which has been exceeded many times in the last two decades (Table 6.2.2). Smog makes breathing more difficult for the elderly and small children, and it can aggravate the conditions of patients suffering from cardiorespiratory diseases. Even healthy young adults breathe less efficiently on days with heavy smog, especially if exercising outdoors. Canada's smog season usually lasts from May to September, and is particularly visible in three regions of the country:

- In the Windsor–Québec corridor, much of the smog is generated locally. However, air pollution from the United States contributes up to about 50% of the ground-level ozone in southern Ontario.
- In the Southern Atlantic Region, parts of Nova Scotia and New Brunswick receive air pollution from the eastern United States. Cross-border pollution contributes between 50% and 80% of the region's smog.
- In the Lower Fraser Valley in British Columbia, 80% of ground-level ozone originates from local sources.

Source:
Environment Canada, 1998, *Smog: Facts*, <http://www.ec.gc.ca/smog/facts.htm>, (accessed August 1, 1999).

Index of the quality of the air

The index of the quality of the air (IQUA) is derived from the measurement of the five NAPS monitored air pollutants, averaged over a period of 1 to 24 hours. Table 6.2.3 shows the total number of days within the different IQUA ranges at selected Canadian cities.

1. Environment Canada, 1996, *Guidelines for the Index of the Quality of the Air*, Environmental Protection Series, Report EPS 1/AP/3, Ottawa.

Table 6.2.1
Average Annual Air Pollution, 1974-1997

Year	Sulphur dioxide	Carbon monoxide[1]	Nitrogen dioxide	Ozone[2]	Total suspended particulates
	percent of NAAQO 'maximum acceptable' levels				
1974	56	47	..	..	112
1975	47	43	..	..	94
1976	52	43	..	..	94
1977	47	34	58	..	88
1978	43	32	55	..	88
1979	43	35	49	109	94
1980	39	32	47	105	96
1981	35	35	43	102	84
1982	35	32	43	99	74
1983	26	28	42	102	68
1984	30	27	45	98	66
1985	26	26	42	93	61
1986	26	26	42	90	61
1987	22	24	40	90	68
1988	26	22	40	113	62
1989	27	21	42	98	62
1990	27	19	39	90	63
1991	20	18	38	86	55
1992	22	19	35	88	50
1993	23	16	35	86	51
1994	22	15	34	92	50
1995	20	14	33	94	51
1996	22	13	32	89	50
1997	22	12	32	90	53

Notes:
1. Over an eight-hour period.
2. Over a one-hour period.

Source:
Environment Canada, Pollution Data Branch.

Table 6.2.2
Number of Days Ground-level Ozone Exceeded NAAQO Objectives[1] in Selected Regions, 1980-1996

	Region				
Year	Atlantic Canada	Lower Mainland of British Columbia	Prairies	Windsor-Québec corridor	Canada
	average number of days				
1980	2.0	4.2	0.7	8.0	5.3
1981	-	9.3	2.3	7.6	6.3
1982	4.0	3.0	1.7	4.5	3.6
1983	..	2.5	0.4	9.6	6.8
1984	17.0	1.2	1.8	4.8	4.1
1985	0.5	2.4	0.3	4.8	3.2
1986	-	1.5	0.3	4.4	3.0
1987	3.0	0.4	0.4	7.1	4.2
1988	3.5	4.5	0.9	17.1	10.5
1989	3.0	0.4	0.9	6.6	4.1
1990	2.0	2.8	0.6	4.0	2.9
1991	5.5	-	0.5	8.2	5.1
1992	0.5	-	-	2.2	1.4
993	0.3	-	0.1	2.1	1.2
1994	1.0	0.5	0.6	3.3	2.1
1995	-	-	0.3	5.6	3.0
1996	-	-	0.1	2.9	1.6

Note:
1. The table shows the annual average number of days on which Canadian urban monitoring stations measured ozone levels exceeding the national maximum acceptable objective (i.e., 82 parts per billion for one-hour average levels) for at least one hour during the day, from May to September.

Source:
Environment Canada, 1999, *Urban Air Quality*, National Environmental Indicator Series, SOE Bulletin No. 99-1, Ottawa.

Table 6.2.3
Air Quality Index[1,2] for Selected Cities, 1990-1995

City/Air quality index	1990	1991	1992	1993	1994	1995
	number of days[3]					
St. John's, Nfld.						
Poor	-	-	-	-	..	-
Fair	25	21	15	2	..	8
Good	40	344	351	363	..	357
Halifax, N.S.						
Poor	..	..	..	1	1	1
Fair	..	..	..	24	22	30
Good	..	..	..	339	342	334
Montréal, Que.						
Poor	3	4	6	3	3	5
Fair	75	59	66	59	54	95
Good	287	303	294	303	308	265
Québec, Que.						
Poor	-	-	7	-	1	..
Fair	52	72	72	70	42	..
Good	313	293	287	295	322	..
Ottawa, Ont.						
Poor	1	4	4	9	3	3
Fair	65	50	59	48	48	53
Good	299	310	303	308	314	309
Toronto, Ont.						
Poor	16	29	9	12	14	14
Fair	136	155	89	110	168	183
Good	213	181	268	243	183	169
Hamilton, Ont.						
Poor	28	31	19	22	22	23
Fair	138	142	112	121	133	158
Good	199	193	236	222	210	184
Winnipeg, Man.						
Poor	15	23	13	3	-	7
Fair	103	68	48	53	267	69
Good	247	274	305	309	298	289
Regina, Sask.						
Poor	19	-	19	6	-	-
Fair	102	58	55	43	59	43
Good	244	307	292	315	306	322
Edmonton, Alta.						
Poor	-	14	15	12	18	14
Fair	158	117	152	136	135	82
Good	207	234	200	216	213	270
Calgary, Alta.						
Poor	1	35	18	44	23	22
Fair	149	156	142	121	132	123
Good	216	174	206	200	210	219
Vancouver, B.C.						
Poor	2	7	-	-	1	-
Fair	37	39	26	32	12	8
Good	326	319	340	333	352	357

Notes:
In order to calculate an index, complete data for ozone and total suspended particulate matter are the minimum requirement.
1. Air pollution measurements were obtained from the National Air Pollution Surveillance Network.
2. Index of the quality of air converts air pollutant data for SO_2, NO_2, CO, O_3 (ozone) and total suspended particulate matter to a common scale. The index is expressed as the number of days of poor-, fair- and good-quality air.
3. The values in the table represent city averages (from all index sites), normalized for 365 days (366 days for 1992).

Source:
Environment Canada, 1997, Air Quality Indicators Database.

Table 6.2.4
Top Five On-site Releases to Air, 1996

Substance	Releases	As share of total
	tonnes	percent
Ammonia (total)[1]	18 198.4	18.5
Methanol	16 161.5	16.5
Xylene (mixed isomers)	6 520.6	6.6
Toluene	6 028.9	6.1
Sulphuric acid	5 650.7	5.8

Note:
1. Refers to the total of both ammonia (NH_3) and ammonium ion (NH_4^+) in solution.
Source:
Environment Canada, Pollution Data Branch, National Pollutant Release Inventory Database, <http://www.ec.gc.ca/pdb/npri/>, (accessed February 1, 1999).

Industry

Industries release hundreds of substances into the air daily.[1] The impacts of these emissions depend on the nature of the substances and the volume released. The National Pollutant Release Inventory (NPRI) records quantities of nearly 180 pollutants released to the Canadian environment.[2] In 1996, 1 818 industrial facilities reported their chemical releases. On-site releases to air represented 68.6% (98 115 tonnes) of the total releases documented in the NPRI.[3] The top five on-site releases to air by weight (excluding the common air pollutants) are outlined in Table 6.2.4.

Effects of weather and climate

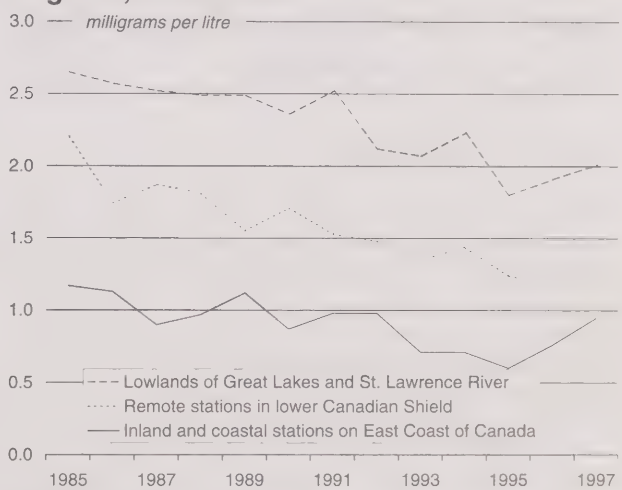
The weather and climate play a critical role in the concentration, dispersion, transport and redistribution of air pollutants, as well as in the chemical reactions they undergo. On days with stagnant weather, air pollution is usually trapped in a shallow layer near the earth's surface; its concentration can reach high levels, particularly from automobile exhaust in large urban areas. On the other hand, pollutants can be carried by winds from urban and industrial regions to rural and less populated areas, sometimes thousands of kilometres from their original source. Measurable concentrations of pesticides have been detected in the Great Lakes and the Arctic and were traced back to distant sources outside North America.[4]

1. Environment Canada, Pollution Data Branch, 1998, *National Pollutant Release Inventory—Summary Report 1996*, Ottawa.
2. There are 176 substances that must be reported under the NPRI. For more information, see <http://www.ec.gc.ca/pdb/npri/>.
3. These figures are subject to change as the NPRI database is continually updated. The data in this report reflect a database extraction conducted on February 1, 1999.
4. Commission for Environmental Co-operation, 1997, *Continental Pollutant Pathways*, Montréal.

Indoor air quality

Indoor air quality is an important occupational and environmental health issue, since most Canadians spend about 90% of their time indoors.[5] The number of complaints related to indoor air quality has increased in recent decades with the trend toward more tightly sealed buildings and energy conservation measures.[6] Indoor air pollutants range from colourless, odourless gases, such as carbon monoxide and radon, to cooking odours, wood smoke, dust and tobacco smoke. Other common irritants and health hazards in the home environment include formaldehyde, polycyclic aromatic hydrocarbons and other compounds, as well as molds, fungi and viruses. Common sources of indoor air pollution include combustion of fossil fuels (e.g., gas stoves, and gas or oil furnaces and heaters), carpets, pets, damp materials, furnishings and consumer products (e.g., glues, cleaning materials, adhesives, paints, solvents and pesticides). Outdoor air pollution (e.g., auto exhaust from garages and loading docks and street dust through air inlets) and the growing use of modern office equipment (e.g., photocopiers, laser printers and computers) also contribute to indoor air quality problems.[7,8]

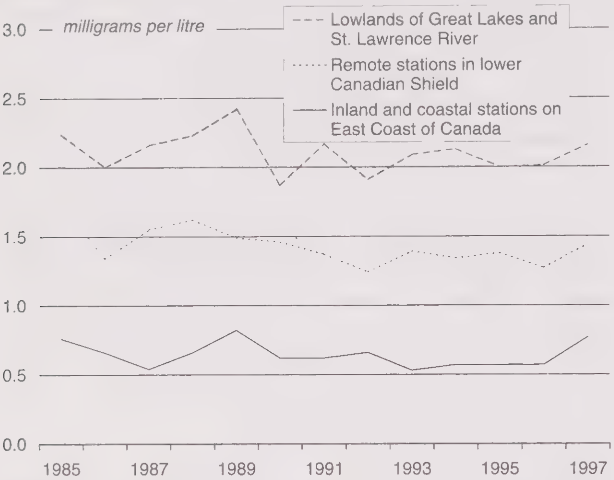
Figure 6.2.3
Trends in Annual Means of Sulphate (SO_4^{2-}) Contained in Acid Precipitation in Selected Regions, 1985-1997



Notes:
The mean values represent the arithmetic averages of the annual precipitation-weighted mean.
It is difficult to measure a national trend as the monitoring sites are all located in eastern Canada, in areas of high acidic deposition.
Source:
Environment Canada, Measurements and Analysis Research Division, Atmospheric Environment Service.

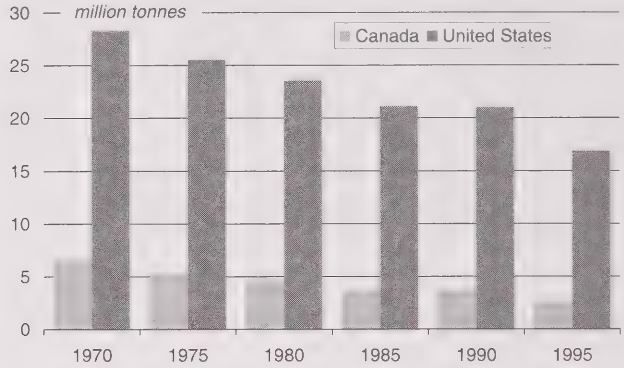
5. Health Canada, 1998, *The Health and Environment Handbook for Health Professionals*, Ottawa.
6. Health Canada, 1995, *Office Air: A Worker's Guide to Air Quality in Offices, Schools and Hospitals*, Report No. 93-EHD-174 (revised), Ottawa.
7. *Ibid.*
8. Health Canada, 1998, *op. cit.*

Figure 6.2.4
Trends in Annual Means of Nitrate (NO_3^-) Contained in Acid Precipitation in Selected Regions, 1985-1997



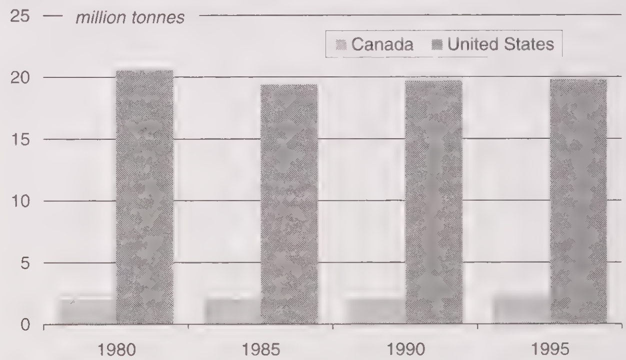
Notes:
The mean values represent the arithmetic averages of the annual precipitation-weighted mean.
It is difficult to measure a national trend as the monitoring sites are all located in eastern Canada, in areas of high acidic deposition.
Source:
Environment Canada, Measurements and Analysis Research Division, Atmospheric Environment Service.

Figure 6.2.5
Sulphur Dioxide Emissions in Canada and the United States, 1970-1995



Note:
Data shown for Canada in 1975 are actually for 1976.
Source:
Environment Canada, 1998, *1997 Canadian Acid Rain Assessment, Volume One: Summary of Results*, Downsview.

Figure 6.2.6
Nitrogen Oxides Emissions in Canada and the United States, 1980-1995



Source:
Environment Canada, 1998, *1997 Canadian Acid Rain Assessment, Volume One: Summary of Results*, Downsview.

6.2.2 Large-scale and long-range air pollutants

Acidic air pollutants

Airborne pollutants such as SO_2 and NO_x undergo chemical reactions in the atmosphere and are converted to sulphuric acid and nitric acid. These acidic aerosols may be carried hundreds of kilometres by winds before returning to earth in various forms of precipitation (rain, fog, hail or snow), commonly known as 'acid rain' (figures 6.2.3 and 6.2.4). Acidic aerosols can cause health complications for people with heart and respiratory conditions (see section 6.6–**Human health**). The haze caused by these particles contributes to low visibility, especially in parts of central and eastern Canada. Damage caused by acid rain affects lakes, rivers, forests, soils and buildings. Acidic deposition can mobilize heavy metals such as copper, cadmium, zinc, aluminium, lead and mercury from soil and bedrock. These metals may subsequently reach humans through the consumption of contaminated plants, animals and drinking water[1] (see section 6.5–**Contaminants in biota**).

Sulphur dioxide (SO_2) emissions in Canada and the United States peaked in the early 1970s and have been declining since then (Figure 6.2.5). This has led to a reduction in the heaviest levels of wet sulphate deposition in eastern North America (Map 6.4.1; see section 6.4–**Soil**). In Canada, areas receiving more than 20 kilograms of SO_2 per hectare declined by 46%.[2] Emissions of NO_x, however, have remained relatively unchanged since the early 1980s (Figure 6.2.6). Motor vehicles are the largest single source, accounting for about 60% of NO_x emissions in Canada.

1. Commission for Environmental Cooperation, *op. cit.*

2. Environment Canada, 1998, *1997 Canadian Acid Rain Assessment, Volume One: Summary of Results*, Downsview.

The greenhouse effect and global warming

Greenhouse gases (GHGs) such as water vapour, carbon dioxide (CO_2) and methane (CH_4) occur naturally in the atmosphere. Human activities, however, are increasing the atmospheric concentrations of CO_2 and other GHGs such as methane, nitrous oxide (N_2O), ozone (O_3) and chlorofluorocarbons (CFCs). This augments the natural greenhouse effect by returning additional energy to the earth, leading to global warming and other changes in weather and climate such as rainfall, wind and storm patterns.[1]

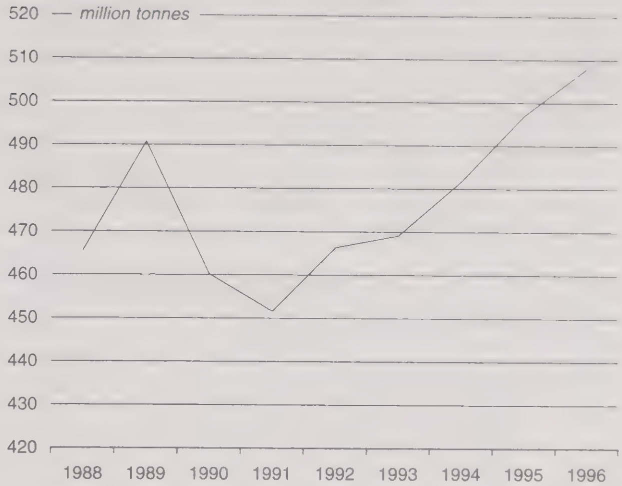
The most abundantly produced gas contributing to this enhanced warming is CO_2, which comes primarily from the burning of fossil fuels and is responsible for about 75% of the human-induced greenhouse effect.[2] Carbon dioxide can remain in the atmosphere for 100 years or more, and today's emissions will still be affecting the global climate at the end of the 21st century. Canada's share of global carbon dioxide emissions was 2.1% in 1996, unchanged from the average for the previous decade—yet Canada has only 0.5% of the world's population.[3] The emissions are high primarily because of Canada's cold climate, vast area and energy-intensive economy. Figure 6.2.7 shows Canadian CO_2 emissions.

Ozone-depleting substances and UV-B radiation

Stratospheric ozone forms a natural protective layer that helps to shield the earth from the harmful effects of the sun's ultraviolet (UV) radiation.[4] UV radiation is divided into three categories of increasing energy: UV-A, UV-B and UV-C. UV-C is very harmful to living organisms and is completely filtered out in the atmosphere before reaching the earth's surface. UV-A and some UV-B have always reached the earth's surface, but since 1980, the total ozone observed in the stratosphere has been declining, allowing more of the harmful UV-B radiation to get through the atmosphere. The leading causes of ozone depletion are emissions of synthetic chemicals. The most common of these are chlorofluorocarbons (CFCs) and halons, which, until recently, were widely used in air conditioners, refrigerators, foams, solvents, aerosols and fire extinguishers (Figure 6.2.8). A single CFC or halon molecule can destroy thousands of molecules of ozone. Since some CFC molecules have life spans of up to 400 years, almost all of the CFCs and halons ever released are still in the atmosphere.[5]

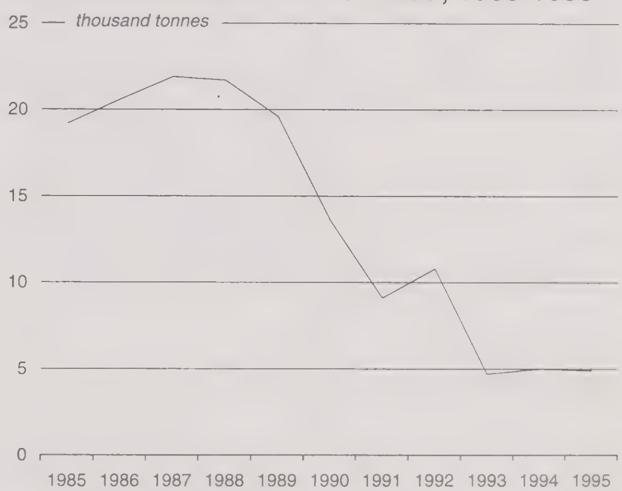
1. For more detail, see section 2.2–**Climate change**.
2. Environment Canada, Pollution Data Branch.
3. *Ibid.*
4. For more information, see section 2.3–**Stratospheric ozone depletion**.
5. Environment Canada, 1998, *Canada's Ozone Layer Protection Program: A Summary*, Ottawa.

Figure 6.2.7
Total Human Activity-Sourced Emissions of Carbon Dioxide in Canada, 1988-1996



Source:
Environment Canada, Pollution Data Branch.

Figure 6.2.8
Total Apparent Consumption of Chlorofluorocarbons in Canada, 1985-1995



Source:
Environment Canada, Pollution Data Branch.

At all levels of government, in industry and in the private sector, Canadians are working to improve air quality for the benefit of their health, ecosystems and future generations. Two examples of initiatives in this area include the vehicle emissions testing conducted by several provinces through Drive Clean programs, and increased reporting of air quality by both the provincial and federal governments.[6]

6. For more information, see section 7.4–**Environmental practices**.

6.3 Water quality

Pollution from human activities can render water unfit for consumption (Text Box 6.3.1). To reduce the risk of harm to human and animal life from polluted water, governments have established guidelines for the maximum concentrations of various pollutants. As shown in Table 6.3.1, the maximum recommended pollutant concentrations are much stricter for water destined for drinking and use by aquatic life than they are for livestock consumption and irrigation.

6.3.1 Sources of water pollution

Water pollution has many sources. Cities contribute pollutants through the discharge of municipal wastewater and through urban run-off. Industries dispose of a variety of chemical and organic wastes directly or indirectly into water bodies. Agricultural activities lead to run-off of plant residues, commercial fertilizers, pesticides and manure into groundwater and surface water.

Table 6.3.1
Maximum Recommended Concentrations of Various Pollutants by Use

Pollutant	Use/Recommended concentration			
	Drinking water[1]	Freshwater aquatic life	Irrigation water	Livestock water
	milligrams per litre			
Benzene	0.005	0.37	...	...
Benzo(a)pyrene	0.00001	0.000015	...	...
Pentachlorophenol	0.03	0.0005	...	..
DDT	0.03	...	...	...
Chloroform	0.1	0.0018	...	...
Methylene chloride	0.05	0.0981	...	0.05
Trichloroethylene	0.05	0.021	...	0.05
Aluminum	...	0.005-0.1	5.0	5.0
Arsenic	0.025	0.005	0.1	0.025
Cadmium	0.005	0.000017	0.0051	0.08
Copper	1.0	0.002-0.004	0.2-1.0	0.5-5.0
Lead	0.01	0.001-0.007	0.2	0.1
Mercury	0.001	0.0001	...	0.003
Nitrate	45.0[2]	...	...	...
Nitrite	3.2	0.06	...	10.0
Dissolved oxygen	5.0-9.5	5.5-9.5	...	...
Total dissolved solids	500	...	500-3 500	3 000
Zinc	5.0	0.03	1.0-5.0	50.0

Notes:
1. These figures are the pretreatment concentrations recommended for water withdrawn from the environment for human consumption.
2. Equivalent to 10 milligrams per litre as nitrogen.

Sources:
Environment Canada and Health Canada, 1995, *Canadian Water Guidelines: Summary of Guidelines for Water Quality in Canada 1995*, Catalogue No. H49-95/1995E, Ottawa.
Environment Canada, *Summary of Canadian water quality guidelines for the protection of aquatic life*, <http://www2.ec.gc.ca./ceqg-rcqe/wattbl_e.doc>, (accessed August 1, 1999).
Environment Canada, *Summary of Canadian water quality guidelines for the protection of agricultural water uses*, <http://www2.ec.gc.ca./ceqg-rcqe/agrtbl_e.doc>, (accessed August 1, 1999).

Text Box 6.3.1
Human Impacts on Water Quality

Dissolved oxygen
The addition of organic matter such as sewage and food processing wastes to a water body can reduce the amount of dissolved oxygen available in the aquatic habitat. A concentration of more than eight parts per million (ppm) of dissolved oxygen is needed to support game fish. Less than two ppm can only support worms, bacteria, fungi and other detritus feeders.[1]

Eutrophication
Eutrophication is a process of excessive plant growth led by an overabundance of nutrients[2] in a water body. When these plants die, their decomposition robs the surrounding water of dissolved oxygen, making the water unsuitable for other forms of aquatic life. Agricultural fertilizers and municipal wastewater, in particular, can greatly enhance the natural nutrient loadings entering a water body. Phosphorus is the key nutrient in the growth of freshwater aquatic plants.

Fecal coliforms
Fecal coliforms are bacteria from the intestinal tracts of warm-blooded animals. Their presence in a water body is evidence of the presence of feces and, therefore, of the risk of contact with infectious agents.

Nitrate contamination
The nitrate ion (NO_3^-) is relatively non-toxic itself but can be converted under certain conditions in an infant's intestinal tract to the nitrite ion (NO_2^{2-}), which is toxic. Nitrite modifies the haemoglobin in blood so that it can no longer carry oxygen, effectively causing suffocation from the inside. Most documented cases of methemoglobinemia (blue baby syndrome) that have been traced to contaminated drinking water have involved nitrogen levels (from nitrate) of more than 40 milligrams per litre—over four times the current safe limit.[3] Sources of nitrate in water include agricultural fertilizers and rural septic systems.

Sedimentation
Sedimentation is the process whereby particles suspended in a water body settle to the bottom and accumulate in layers. It is a natural process that can be accelerated by human activities such as forestry, agriculture and construction. An example of the impact of excessive sedimentation is the smothering of feeding and spawning grounds of fish.

1. Cunningham, W.P. and B. Woodworth Saigo, 1995, *Environmental Science, Third Edition*, William C. Brown Publishers, Chicago.
2. Any substance required by organisms for normal growth and maintenance.
3. Reynolds, W.D. *et al.*, 1995, "Agrochemical Entry into Groundwater," in D.F. Acton and L.J. Gregorich (eds.), *The Health of Our Soils: Toward Sustainable Agriculture in Canada*, Agriculture and Agri-Food Canada, Catalogue No. A53-1906/1995E, Centre for Land and Biological Resources Research, pp. 97-109, Ottawa.

Municipal wastewater

Wastewater from towns and cities can have a considerable impact on the quality of the water bodies into which it is released.[1] Serious oxygen depletion may occur downstream from a wastewater treatment plant, especially with ice cover in winter. Treated wastewater, which contains some residues from the treatment process, can introduce ammonia, heavy metals, organic compounds, excess nutrients (particularly phosphorus) and pathogens to the receiving water body.[2]

The degree to which wastewater affects water quality depends in part upon the treatment it receives before release. In the worst case, wastewater is released directly to the receiving water body with no treatment. Fortunately, this is no longer common in Canada; most towns and cities today treat their wastewater before release. The facilities in which wastewater is treated provide one of three levels of treatment:

- *primary treatment* removes insoluble matter only;
- *secondary treatment* removes biological impurities from water treated at the primary level; and
- *tertiary treatment* removes nutrients and chemical contaminants remaining after secondary treatment.

In 1996, an estimated 13.9 billion litres of treated effluent were discharged daily from municipal sewage treatment plants.[3] Table 6.3.2 shows the level of wastewater treatment received by the population served by municipal sewers between 1983 and 1996. As can be seen, the share of individuals who received no wastewater treatment fell from 28% in 1983 to 6% in 1996. Over the same period, the share receiving the highest level (tertiary) of wastewater treatment rose from 28% to 41%.

Industry

Industries discharge hundreds of substances into rivers and lakes daily.[4] The impacts of these discharges depend on the nature of the substances and the volume released. For example, one billion litres of water can become unsuitable for freshwater aquatic life with the discharge of only one gram of polychlorinated biphenyls (PCBs).[5]

The National Pollutant Release Inventory (NPRI) records quantities of nearly 180 pollutants released to the Canadian environment.[6] In 1996, 1 818 industrial facilities reported their chemical releases. On-site releases to water represented 9.1% (13 027 tonnes) of the total releases documented in the NPRI.[7] The top five on-site releases to water by weight are outlined in Table 6.3.3. Table 6.3.4 lists the water bodies that received the most reported pollutants from industrial sources in 1996. Ammonia (1 934 tonnes) was the number one pollutant released in the Saint John River while nitrate ion (1 450 tonnes) was the top pollutant in the St. Lawrence River.

Table 6.3.2
Municipal Wastewater Treatment Level for Population Served with Sewers,[1] Various Years

Year	Treatment level[2]			
	None	Primary	Secondary[3]	Tertiary
	percent			
1983[4]	28	16	28	28
1986[4]	28	15	26	31
1989[4]	19	20	29	32
1991	15	20	29	37
1994	7	23	31	39
1996	6	22	30	41

Notes:
1. Includes those served by municipal septic trucks.
2. Although a small percentage of the rural population is reported to receive municipal wastewater treatment in the Municipal Water Use Database, the database does not provide information on the level of treatment received by these rural dwellers. For the purposes of this table, the rural populations receiving wastewater treatment in each province have been distributed among the four treatment levels by assuming that rural dwellers receive the same level of treatment as their urban neighbours. That is, the share of urban residents covered by each level of treatment was applied to that segment of the rural population that reported receiving municipal wastewater treatment.
3. Includes waste stabilization ponds, or sewage lagoons, which are simple wastewater treatment systems capable of delivering treatment equivalent to that of a secondary wastewater treatment facility.
4. The data for 1983, 1986 and 1989 do not include the population in rural areas served by municipal wastewater systems, whereas those for later years do. Since only a small percentage of the rural population receives municipal wastewater treatment, its exclusion in the earlier years does not seriously affect the comparability of the time series.

Source:
Environment Canada, Municipal Water Use Database.

Table 6.3.3
Top Five On-site Releases to Water, 1996

Substance	Releases	Share of total
	tonnes	percent
Ammonia (total)[1]	5 971.6	45.8
Nitrate ion in solution at pH 6.0	3 138.9	24.1
Methanol	2 172.0	16.7
Zinc and its compounds	341.4	2.6
Manganese and its compounds	288.9	2.2

Note:
1. Refers to the total of both ammonia (NH_3) and ammonium ion (NH_4^+) in solution.

Source:
Environment Canada, Pollution Data Branch, National Pollutant Release Inventory Database, <http://www.ec.gc.ca/pdb/npri/>, (accessed February 1, 1999).

1. For more information, see subsection 6.1.6–**Municipal wastewater**.
2. Alberta Environmental Protection, 1998, *1996 Alberta State of the Environment Report—Aquatic Systems*, Edmonton.
3. Environment Canada, Municipal Water Use Database.
4. Environment Canada, Pollution Data Branch, 1998, *National Pollutant Release Inventory—Summary Report 1996*, Ottawa.
5. Environment Canada, *Water is the Lifeblood of the Earth*, <http://www.ec.gc.ca/water/index.htm>, (accessed May 5, 1999).
6. There are 176 substances that must be reported under the NPRI. For more information, see <http://www.ec.gc.ca/pdb/npri/>.
7. These figures are subject to change as the NPRI database is continually updated. The data in this report reflect a database extraction conducted on February 1, 1999.

Table 6.3.4
Water Bodies Receiving Over 500 Tonnes of Pollutants, 1996

Water body	Release	Share of total
	tonnes	percent
Saint John River, N.B.	2 468	18.9
St. Lawrence River, Que. and Ont.	1 967	15.1
Detroit River, Ont.	849	6.5
St. Mary's River, Ont.	665	5.1
Columbia River, B.C.	660	5.1
Ottawa River, Que. and Ont.	597	4.6
South Saskatchewan River, Alta.	537	4.1

Notes:
The information in this table is not intended to be an assessment of environmental impact or water quality.
The totals do not include releases to tributaries of the named rivers.
Source:
Environment Canada, Pollution Data Branch, National Pollutant Release Inventory Database, <http://www.ec.gc.ca/pdb/npri/>, (accessed February 1, 1999).

Agriculture

Over the past several decades, Canadian crop and livestock outputs have increased considerably. New technologies involving mechanization, genetics, nutrient science, and irrigation have fostered these increases. The use of these new technologies has not come without environmental costs, including the degradation of water quality.

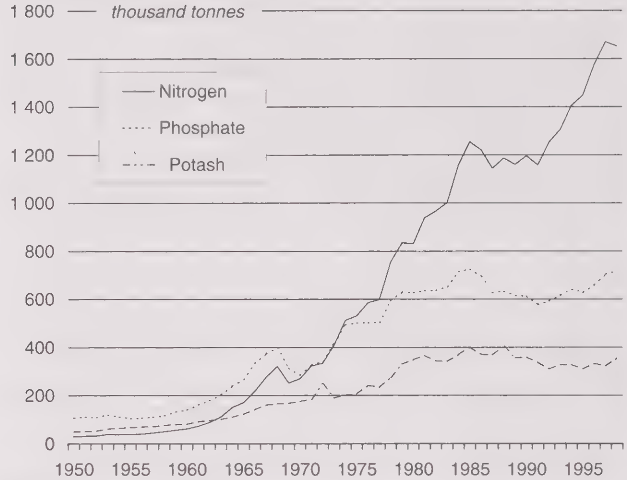
Agricultural impacts on water quality are often due to non-point pollution sources—those that are spread out and cover large geographic areas, making exact sources difficult to find. For example, commercial fertilizers, livestock manure and pesticides all have a potential impact on water quality.

Commercial fertilizers

One of the most important inputs to agriculture is manufactured fertilizer nutrients.[1] Potential impacts of fertilizers on water quality include the introduction of suspended and dissolved nutrients into surface water bodies and groundwater. For the most part, these impacts occur during episodes of intense rainfall. Under ideal conditions and at optimum application rates, fertilizers have minimal water quality impacts and are consumed almost entirely by the target crop. It should also be noted that the water quality impacts of fertilizers vary significantly across the country and are related to soil type, rainfall, crop conditions and characteristics of the receiving water body.

1. Refers only to the macronutrients nitrogen, phosphate and potash.

Figure 6.3.1
Nutrient Content of Fertilizers Sold in Canada, 1950-1998



Source:
Korol, M. and G. Rattray, 1999, *Canadian Fertilizer Consumption, Shipments and Trade, 1997/1998*, Agri-Food and Agriculture Canada, Farm Income Policy and Programs Directorate, Ottawa.

The nutrient content of fertilizer has increased steadily as more concentrated and more easily applied fertilizer products have been developed. Figure 6.3.1 shows the increase in fertilizer nutrient content from 1950 to 1998. During this period, the nitrogen content in fertilizer grew the fastest.

Table 6.3.5
Nitrogen, Phosphate and Potash Content of Commercial Fertilizer Applied on Farmland by Ecozone, 1970 and 1995

	Nitrogen			Phosphate			Potash		
Ecozone[1]	1970	1995	Change 1970-1995	1970	1995	Change 1970-1995	1970	1995	Change 1970-1995
	tonnes		percent	tonnes		percent	tonnes		percent
Boreal Shield	4 241	13 994	229.9	5 614	7 893	40.6	5 407	8 686	60.6
Atlantic Maritime	15 335	35 828	133.6	25 408	29 911	17.7	24 988	33 660	34.7
Mixed Wood Plains	117 920	265 208	124.9	121 864	136 472	12.0	114 592	196 904	71.8
Boreal Plains	25 008	237 331	849.0	27 098	95 656	253.0	998	18 518	1 755.5
Prairie	77 485	779 927	906.5	75 316	314 069	317.0	2 253	56 925	2 426.8
Montane Cordillera	2 582	10 291	298.6	2 241	4 409	96.7	1 011	2 448	142.0
Pacific Maritime	4 530	19 285	325.8	3 961	8 299	109.5	1 911	4 699	145.9
Canada	**247 101**	**1 361 863**	**451.1**	**261 501**	**596 709**	**128.2**	**151 161**	**321 840**	**112.9**

Notes:
Figures may not add up to totals due to rounding.
1. Limited to those with agricultural activity.
Sources:
Statistics Canada, Environmental Accounts and Statistics Division, and Agriculture Division.

Table 6.3.6
Nitrogen and Phosphate Content of Animal Manures Produced on Farms by Ecozone, 1970 and 1995

Ecozone[1]	Nitrogen from agricultural animal manures 1970	1995	Change 1970-1995	Phosphate from agricultural animal manures 1970	1995	Change 1970-1995
	tonnes		percent	tonnes		percent
Boreal Shield	29 459	22 648	-23.1	14 050	10 835	-22.9
Atlantic Maritime	49 313	45 510	-7.7	23 773	22 790	-4.1
Mixed Wood Plains	208 500	190 398	-8.7	102 543	95 679	-6.7
Boreal Plains	62 842	91 313	45.3	31 383	44 912	43.1
Prairie	204 348	238 690	16.8	100 994	118 051	16.9
Montane Cordillera	14 445	18 632	29.0	6 822	8 707	27.6
Pacific Maritime	10 747	15 565	44.8	4 645	6 688	44.0
Canada	**579 654**	**622 756**	**7.4**	**284 210**	**307 662**	**8.2**

Notes:
Figures may not add up to totals due to rounding.
Calculations for the amount of nitrogen and phosphate per animal are based on 1974 Agriculture Canada coefficients.
1. Limited to those with agricultural activity.
Sources:
Statistics Canada, Environmental Accounts and Statistics Division, and Agriculture Division.

Table 6.3.7
Agricultural Pesticide Expenditures and Application Rates by Ecozone, 1970 and 1995

Ecozone[1]	Total agricultural pesticide expenditures 1970	1995	Change 1970-1995	Agricultural pesticide applied per km² of cultivated land 1970	1995	Change 1970-1995
	1990 dollars		percent	1990 dollars		percent
Boreal Shield	2 607 889	7 660 443	193.7	298	1 098	268.4
Atlantic Maritime	13 100 429	33 109 343	152.7	1 080	3 545	228.3
Mixed Wood Plains	88 433 803	211 800 054	139.5	1 692	4 408	160.5
Boreal Plains	12 700 961	130 895 084	930.6	174	1 512	768.6
Prairie	47 033 763	540 946 447	1 050.1	169	1 807	966.3
Montane Cordillera	5 639 076	8 236 737	46.1	2 190	6 581	200.5
Pacific Maritime	3 489 107	8 639 126	147.6	2 076	2 290	10.3
Canada	**173 005 028**	**941 287 234**	**444.1**	**404**	**2 067**	**411.3**

Notes:
Figures may not add up to totals due to rounding.
Farm input price indices were used to obtain 1990 constant dollar expenditures.
1. Limited to those with agricultural activity.
Sources:
Statistics Canada, Environmental Accounts and Statistics Division, and Agriculture Division.

Close to 2.3 million tonnes of potash, phosphate and nitrogen from commercial fertilizers was applied to Canadian farms in 1995 (Table 6.3.5). All ecozones[1] with agricultural activity experienced increases in the application of these fertilizers between 1970 and 1995.

Livestock manure

Livestock manure was typically not a pollution problem on traditional mixed farms where nutrients were cycled between crop and livestock. On today's much larger, more specialized farms, however, manure production rates are so high that manure is often a waste product. Manure nutrients can pollute surface water bodies and groundwater, ultimately affecting the health of humans, livestock and wildlife reliant on that water. When manure is stored properly and applied to fields in appropriate quantities, it has limited impact on water quality.

In 1995, approximately 623 000 tonnes of nitrogen and 308 000 tonnes of phosphate were produced by animal manures on Canadian farms (Table 6.3.6).[2] The bulk of manure nitrogen and phosphate production occurred in the Mixed Wood Plains and Prairie ecozones. Changes in nitrogen and phosphate production largely reflect changing livestock population levels and species composition.

Agricultural pesticides

Agricultural pesticides are applied to control insects, weeds and crop diseases in an effort to maintain crop quantity and quality. When the proper pesticide is applied carefully under favourable environmental conditions, impacts on water quality are minimized.

1. For more information on ecozones, see section 3.1–**Environmental geographies**.

2. These amounts of nutrients are equivalent to approximately 50% of the nitrogen and phosphate from commercial fertilizers.

Close to $1 billion was spent on agricultural pesticides in 1995 (Table 6.3.7). That is, for every square kilometre of land cultivated, $2 067 was spent on agricultural pesticides. Between 1970 and 1995, agricultural pesticide expenditures increased by 411%.

6.3.2 Regional water quality

Regional variations in water quality exist because water pollution levels and the aquatic environment's resilience to pollution vary considerably across the country.

Atlantic provinces

Despite its size, the ocean is not immune to the effects of urban, industrial and agricultural pollution. Beaches have been closed to swimming because of high coliform counts and the health of aquatic life has also been affected.[1]

The closure of shellfish harvesting areas is often used as an indicator of water quality. Many types of shellfish[2] feed by filtering suspended particles out of the water that washes over them; a single mussel may filter up to 300 times its weight in water per hour. Through this filtration process, these organisms concentrate both chemical and natural pollutants in their tissues. In the Atlantic provinces, there has been an increase in the closure of harvesting areas as result of the contamination of shellfish (Table 6.3.8).

Acid rain continues to be a concern in the Atlantic provinces. Between 1981 and 1994, 9% of the lakes in the region deteriorated in quality, 79% were stable and 12% improved.[3]

Groundwater contamination is an important issue in the Atlantic provinces, given that approximately 90% of the rural population relies on groundwater.[4] Studies have found elevated nitrate concentrations and pesticides in some groundwater wells in the Atlantic provinces.[5]

Great Lakes and St. Lawrence River

The Great Lakes drainage basin, the source of much of Canada's economic output, is home to more than half of the Canadian population and to more than 30 million American citizens. Although this area comprises only 9% of the nation's agricultural land, it contributes about 40% of Canada's agricultural production.[6] Intense land use and the accumulation of pollutants draining from one lake to the next have long created water quality problems in the lower lakes and the St. Lawrence River.

Pathogens in raw sewage caused cholera and typhoid epidemics in the early 1900s; phosphates caused eutrophication and excessive algal growth in the 1960s and

Table 6.3.8
Shellfish Areas on the Atlantic Coast and in the Gulf of St. Lawrence, 1989-1998

	Atlantic Coast			Gulf of St. Lawrence		
Year	Areas approved for harvesting	Areas with conditional approval	Areas closed to harvesting	Areas approved for harvesting	Areas with conditional approval	Areas closed to harvesting
	km^2					
1989	2 728	42	1 676	...	...	...
1990	2 917	74	1 795	...	...	...
1991	3 107	88	1 908	...	...	...
1992	3 296	74	1 947	59	31	81
1993	3 539	83	2 009	...	...	...
1994	3 678	83	2 076	76	26	89
1995	3 685	73	2 092	...	...	...
1996	3 471	68	1 958	76	26	89
1997	4 017	52	2 062	80	27	89
1998	...	...	...	56	20	120

Note:
Area surveyed may vary annually. Year-to-year comparisons should be made with caution.
Source:
Environment Canada, Atlantic and Quebec regions.

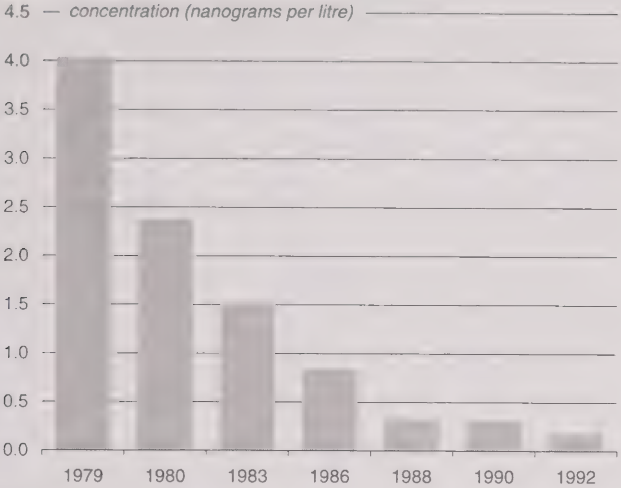
Table 6.3.9
Critical Pollutants in the Great Lakes

Substance	Description
PCBs (209 related chemicals)	insulating fluid in transformers, hydraulic fluid, lubricant; major disposal problems
DDT and its breakdown products, including DDE	insecticides (now banned in Canada and United States)
Aldrin and dieldrin	insecticides
Toxaphene (hundreds of related chemicals)	insecticide (now banned in Canada and United States)
2,3,7,8-TCDD (tetrachlorodibenzo-p-dioxin)	waste by-product of combustion and some industrial processes using chlorine
2,3,7,8-TCDF (tetrachlorodibenzofuran)	waste by-product of combustion and some industrial processes using chlorine
Mirex	pesticide, industrial fire retardant; no longer used
Mercury	formerly used in paints, electrical equipment, and pulp and paper production; released during coal combustion
Benzo(a)pyrene, representative of polycyclic aromatic hydrocarbons (PAHs)	by-product of incomplete combustion
Hexachlorobenzene (HCB)	pesticide
Alkylated lead	gasoline additive (banned in 1988)

Source:
Environment Canada, 1996, *The State of Canada's Environment 1996*, Ottawa.

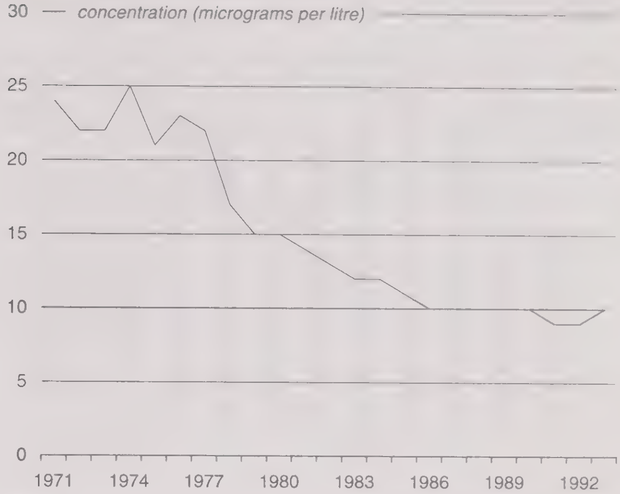
1. Environment Canada, *Water—An Ecosystem Perspective*, <http://www.ec.gc.ca/water/en/info/pubs/primer/e_prim05.htm>, (accessed May 3, 1999).
2. Includes molluscs (e.g., oyster, clam, mussel, cockle and quahog) and crustaceans (e.g., lobster, crab and shrimp).
3. Environment Canada, 1997, *Acid Rain*, National Environmental Indicator Series, SOE Bulletin No. 96-2, Ottawa.
4. Environment Canada, 1996, *The State of Canada's Environment 1996*, Ottawa.
5. *Ibid.*
6. *Ibid.*

Figure 6.3.2
PCB Concentrations in Lake Superior, Selected Years



Note:
All data are for 82 PCB congeners.
Source:
Jeremiason, J.D., K.C. Hornbuckle and S.J. Eisenreich, 1994, "PCBs in Lake Superior, 1978–1992: Decreases in Water Concentrations Reflect Loss by Volatilization," *Environmental Science and Technology*, Vol. 28, pp. 903-913.

Figure 6.3.3
Average Phosphate Concentrations in Lake Ontario, 1971-1993



Note:
Average phosphate concentration corresponds to annual mean surface values from several hundred open water samples (mainly during the spring and the summer).
Source:
Environment Canada, Ontario Region.

1970s; and the effects of persistent toxic chemicals on fish, birds and mammals can still be seen[1] (see section 6.5–**Contaminants in biota**). Eleven chemical pollutants found in the Great Lakes are of special concern because of their toxicity, persistence in the environment and tendency to bioaccumulate (Table 6.3.9).

Among the Great Lakes, Lake Superior has the lowest levels of many toxic substances since large population centres and industrial operations are located on the lower lakes.[2] In the early 1990s, PCB concentrations in Lake Superior were only one-third of those in lakes Michigan and Huron and one-sixth of those in lakes Erie and Ontario.[3]

As Figure 6.3.2 shows, a decrease in PCB concentrations in Lake Superior has been observed since 1979, but the decrease has slowed down in recent years. This trend parallels that found in fish and herring gull eggs for all the lakes[4] (see section 6.5–**Contaminants in biota**).

The main culprits in the eutrophication of the Great Lakes and the St. Lawrence River are phosphates, with agriculture and municipal wastewater the main sources. In recent years, phosphate loadings in lakes Erie and Ontario have been reduced significantly. Average phosphate concentrations in Lake Ontario fell from 24 micrograms per litre in 1971 to 10 micrograms per litre in 1993 (Figure 6.3.3).

Prairie provinces

The eutrophication of lakes is a general concern in the Prairie provinces, as is contamination resulting from the widespread use of herbicides and insecticides. The infiltration of nitrate into groundwater is a chronic problem for the more than 25% of the Prairie population that relies upon wells for its water supply.[5]

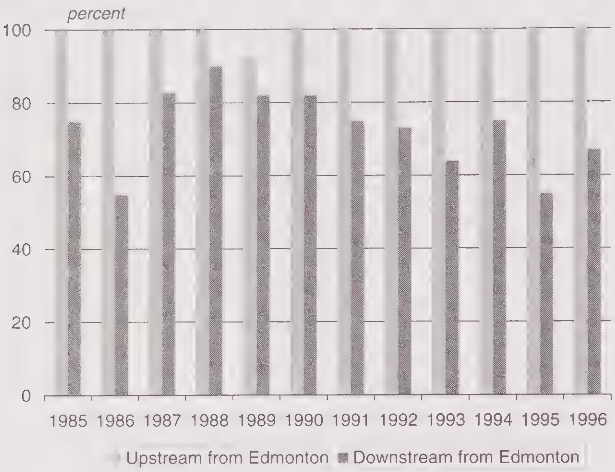
The water quality in the North Saskatchewan River is illustrative of that in other major rivers in Alberta. The basin of the North Saskatchewan has one million inhabitants (most in and around Edmonton), significant industry (chemical plants and refineries) and a thriving agriculture industry. As shown in Figure 6.3.4 and Table 6.3.10, these pressures result in water quality that is much lower downstream from Edmonton than upstream.

Pacific Coast

In 1996, British Columbia assessed water quality in 124 water bodies of concern across its seven districts (Table 6.3.11). Each water body was assessed with respect to six uses: drinking, recreation, irrigation, livestock watering, aquatic life and wildlife sustenance. Concentrations of pollutants (fecal coliforms, suspended solids and heavy metals) were compared with established water

1. Environment Canada, 1996, *The State of Canada's Environment 1996*, Ottawa.
2. Environment Canada, 1997, *Discover the Great Lakes: The Ecosystem of the Great Lakes–St. Lawrence*, Catalogue No. En21-160/1997E-MRC, Ottawa.
3. Jeremiason, J.D., K.C. Hornbuckle and S.J. Eisenreich, 1994, "PCBs in Lake Superior, 1978-1992: Decreases in Water Concentrations Reflect Loss by Volatilization," *Environmental Science and Technology*, Vol. 28, pp. 903–913.
4. *Ibid.*
5. Environment Canada, 1996, *The State of Canada's Environment 1996*, Ottawa.

Figure 6.3.4
Compliance with the Fecal Coliform Guideline in the North Saskatchewan River, 1985-1996



Note:
Follows the fecal coliform guideline of Saskatchewan.
Source:
Government of Alberta, 1998, *Measuring Up—Fourth Annual Report on the Performance of the Government of Alberta, 1997-98 Results*, Edmonton.

quality objectives. Many of the instances of poor water quality were found to be caused by water-borne infectious organisms.

In the late 1980s, dioxins and furans were found in high concentrations in sediments, fish and shellfish along the British Columbia coast and up the Fraser River. A number of pulp mills using chlorine bleaching were in operation in this general area (at Prince George, Quesnel and Williams Lake). Dioxin and furan levels were highest just downstream from the northernmost mills and decreased gradually towards Vancouver. All 17 chlorine-bleaching mills have since improved the quality of their wastewater streams; by the mid-1990s dioxin and furan levels had fallen by between 50% and 90% in some areas[1] (see subsection 6.1.4–**Releases of dioxins and furans**).

As noted earlier, closure of shellfish harvesting areas is one indicator of deteriorated water quality. In general, shellfish harvesting area closings on the Pacific Coast have been on the rise (Table 6.3.12). However, it is not clear whether this is an indication of deteriorating water quality, as many of the recent closures have resulted from new monitoring activities.

1. Environment Canada, 1996, *The State of Canada's Environment 1996*, Ottawa.

Table 6.3.10
Water Quality Index for Major Alberta Rivers by Use, 1996

	Use/Water quality[1]			
River	Recreation	Aquatic life	Agriculture	Stresses
Smoky/Peace				
at Watimo	poor	fair	good	pulp mill and
at Fort Vermillion	poor	fair	good	municipal sources
Athabasca				
at Athabasca	poor	fair	fair	pulp mill and
at Old Fort	poor	fair	fair	municipal sources
North Saskatchewan				
upstream from Edmonton	fair	good	good	municipal, industrial
downstream from Edmonton	unacceptable	fair	good	and agricultural sources
Red Deer				
upstream from Red Deer	fair	good	good	municipal, industrial
downstream from Red Deer	poor	fair	good	and agricultural sources
Bow				
upstream from Calgary	good	good	good	municipal and
downstream from Calgary	unacceptable	fair	good	agricultural sources; reduced flow from water withdrawal
Oldman				
upstream from Lethbridge	poor	fair	good	municipal and
downstream from Lethbridge	unacceptable	fair	good	agricultural sources

Note:
1. Water quality: 'good' corresponds to 96-100% compliance with Alberta water quality guidelines; 'fair' to 86-95% compliance; 'poor' to 71-85% compliance; and 'unacceptable' to 70% compliance or less.
Source:
Government of Alberta, 1998, *Measuring Up—Fourth Annual Report on the Performance of the Government of Alberta, 1997-98 Results*, Edmonton.

Table 6.3.11
Water Quality Index in 124 Water Bodies in British Columbia, 1996

	Water quality index[1]				
Region	Excellent	Good	Fair	Borderline	Poor
	number of water bodies				
Cariboo	-	-	-	1	-
Kootenay	-	3	2	-	-
Lower Mainland	5	18	30	1	1
Omineca-Peace	2	2	6	2	-
Skeena	-	3	5	-	1
Southern interior	1	14	15	1	2
Vancouver Island	1	4	2	1	1
Total	**9**	**44**	**60**	**6**	**5**

Note:
1. Water quality (based on British Columbia water quality guidelines): 'excellent' means all uses of water are protected and none are threatened or impaired; 'good' means all uses are protected with only a minor degree of threat or impairment; 'fair' means most uses are protected but a few are threatened or imparied; 'borderline' means several uses are protected but a few are threatened or impaired; and 'poor' means most uses are threatened, impaired or even lost.
Source:
British Columbia Ministry of Environment, Lands and Parks, 1996, *British Columbia Water Quality Status Report*, Victoria.

Table 6.3.12
Shellfish Areas Closed on the Pacific Coast, by Source of Pollution, 1972-1995

Year	Pollution source: Multiple sources	Municipal discharges	Vessel discharges	Urban run-off	Agricultural run-off	Total area closed
	km^2					
1972	454	52	5	4	1	517
1973	..	..	..	..	..	..
1974	..	..	..	..	..	..
1975	..	..	..	..	..	..
1976	462	60	3	6	3	534
1977	462	64	3	10	4	543
1978	457	65	3	11	5	540
1979	435	65	3	8	5	517
1980	..	..	..	..	..	..
1981	440	69	3	8	6	527
1982	..	..	..	..	..	..
1983	..	..	..	..	..	..
1984	445	71	14	12	6	547
1985	..	..	..	..	..	..
1986	..	..	..	..	..	..
1987	485	59	15	6	3	568
1988	572	103	13	7	32	727
1989	551	93	13	7	45	710
1990	551	102	14	7	45	719
1991	551	112	14	9	40	725
1992	552	108	14	8	39	721
1993	551	108	15	7	43	724
1994	566	109	212	8	45	940
1995	566	109	213	8	45	940

Note:
Area surveyed may vary annually. Year-to-year comparisons should be made with caution.
Source:
Environment Canada, Pacific and Yukon Territory Region.

6.4 Soil

Soil is the foundation of most terrestrial ecosystems, providing plants with air, water, nutrients and physical support. Soil also yields other vital ecosystem functions: it recycles nutrients by providing a home for detritivores,[1] and it mitigates flooding by absorbing rainfall. These functions can be degraded both physically and chemically by human activity.

6.4.1 Physical degradation

Physical degradation is the result of human activities and natural processes that damage soil structure. It is generally associated with soils used for agriculture or forestry.

Erosion

Globally, erosion is the most serious cause of soil degradation.[2] It occurs when wind or water moves soil. It has consequences beyond soil quality, since eroded soil can interfere with drainage ditches and reservoirs.[3] It can also alter aquatic habitats through sedimentation and the release of nutrients and pesticides present in the eroded soil. Erosion in excess of the natural rate of regeneration (1 cm in 120 to 400 years)[4] reflects a gradual loss of Canada's productive farmland.

Erosion is a natural process that is significantly increased when earth is exposed by the removal of its vegetative cover (Table 6.4.1). The risk of wind and water erosion on bare agricultural soils in Canada is outlined in tables 6.4.2 and 6.4.3. These inherent risks can be lowered by appropriate land management. With the farm management practices used in 1991, the cultivated area at high and severe risk of wind erosion was less than 5% for the Prairie provinces (well below the inherent risk of 36% found in Table 6.4.2). The corresponding risk for water erosion was 2% in the Prairie provinces and 5% in Ontario.[5]

Table 6.4.1
Rates of Erosion Under Different Soil Covers

Soil cover	Annual loss	Time required to erode 10 centimetres
	tonnes per hectare	years
Sod	0.76	1 711
Corn-wheat-clover rotation	6.23	207
Continuous wheat	22.64	56
Continuous corn	44.19	28
Ploughed and uncultivated	92.06	13

Source:
Cox, G.W. and M.D. Atkins, 1979, *Agricultural Ecology: An Analysis of World Food Production Systems*, W.H. Freedman, San Francisco.

Table 6.4.2
Inherent Risk of Wind Erosion of Bare Soil on the Cultivated Land of the Prairie Provinces

Risk class	Manitoba	Saskatchewan	Alberta	Prairie provinces
	percent of cultivated land			
Negligible (under 6.0 tonnes/hectare/year)	8	4	7	6
Low (6.0 to 10.9 tonnes/hectare/year)	37	23	39	31
Moderate (11.0 to 21.9 tonnes/hectare/year)	19	34	24	29
High (22.0 to 32.9 tonnes/hectare/year)	30	33	27	30
Severe (over 32.9 tonnes/hectare/year)	5	7	4	6

Note:
Wind erosion is a problem in many regions, but it is most extensive and damaging in the Prairie provinces.
Source:
Wall, G.J. *et al.*, 1995, "Erosion," in D.F. Acton and L.J. Gregorich (eds.), *The Health of Our Soils: Toward Sustainable Agriculture in Canada*, Centre for Land and Biological Resources Research, Agriculture and Agri-Food Canada, Catalogue No. A53-1906/1995E, pp. 61-76, Ottawa.

Table 6.4.3
Inherent Risk of Water Erosion of Bare Soil on Canada's Cultivated Land

Risk class[1]	P.E.I.	N.S.	N.B.	Que.	Ont.	Man.	Sask.	Alta.	B.C.	Canada[2]
	percent of cultivated land									
Negligible	1	3	-	18	12	35	51	39	5	40
Low	7	6	4	21	11	41	26	16	8	23
Moderate	11	4	16	14	24	6	19	17	13	17
High	37	3	13	4	25	4	3	10	3	7
Severe	44	84	67	43	27	14	1	18	72	13

Notes:
1. Rates of erosion for each risk class are given in Table 6.4.2.
2. Figures for Newfoundland were not provided in the source document.
Source:
Wall, G.J. *et al.*, 1995, "Erosion," in D.F. Acton and L.J. Gregorich (eds.), *The Health of Our Soils: Toward Sustainable Agriculture in Canada*, Centre for Land and Biological Resources Research, Agriculture and Agri-Food Canada, Catalogue No. A53-1906/1995E, pp. 61-76, Ottawa.

Structural impacts

Compaction, breakdown of soil structure and depletion of organic matter are other forms of physical degradation. Compaction occurs when heavy machinery, such as tractors, is used on wet soils. Structural breakdown, a consequence of excessive tillage, results from the continued pulverization of soil crumbs. Organic matter is lost as it gradually decomposes, a process accelerated by the changes in moisture, aeration and temperature associated with cultivation.

1. Detritivores include worms and other organisms that feed on decaying plant and animal matter. By doing so, they accelerate the decomposition of this organic matter, releasing the nutrients it contains in the process.
2. Soule, J., D. Carre and W. Jackson, 1990, "Ecological Impact of Modern Agriculture," in C.R. Carroll J.H. Vandermeer and P.M. Ross (eds.), *Agroecology*, McGraw-Hill, pp. 165–188, New York.
3. Wall, G.J. *et al.*, 1995, "Erosion," in D.F. Acton and L.J. Gregorich (eds.), *The Health of Our Soils: Toward Sustainable Agriculture in Canada*, Centre for Land and Biological Resources Research, Agriculture and Agri-Food Canada, Catalogue No. A53-1906/1995E, pp. 61–76, Ottawa.
4. Soule, J. *et al.*, *op. cit.*

5. Wall, G.J. *et al.*, *op. cit.*

Table 6.4.4
Tillage Practices on Land Prepared for Seeding, 1991 and 1996

Type of tillage	1991	1996	Change 1991-1996
	hectares		percent
Conventional tillage	19 986 611	15 334 293	-23.3
Conservation tillage	7 091 001	8 766 760	23.6
No tillage	1 951 154	4 591 779	135.3
Total	**29 028 766**	**28 692 832**	**-1.2**

Source:
Statistics Canada, 1997, *Historical Overview of Canadian Agriculture*, Catalogue No. 93-358-XPB, Ottawa.

Structural degradation can lead to a disruption of the water-, nutrient- and air-holding capacities of soil and contribute to erosion. Compaction encourages run-off by impeding the infiltration of water into the soil; structural breakdown produces fine soil particles that are more easily carried away by wind and water; and the loss of organic matter leads to more erodable soil particles.[1,2]

Conservation tillage, various crop rotations, no-till agriculture and the use of green manures and other soil amendments are means of maintaining and improving soil structure (for details on these practices, see Text Box 5.1.3 in section 5.1–**Agricultural resources**). Table 6.4.4 shows the increase in conservation tillage practices in Canada between 1991 and 1996.

6.4.2 Chemical contamination

Human activity also damages soils through exposing them to pollutants, and through practices that increase the presence of naturally occurring substances such as salts and heavy metals.

Large-scale and long-range contamination

Some chemicals are so commonly used or are produced in such abundance that they are found in soil across the country. Examples include petroleum products (Text Box 6.4.1), polychlorinated biphenyls (PCBs) and the pesticide DDT. Several of these pollutants travel on air currents, affecting large areas far from their source.

Acid precipitation is a case of both large-scale and long-range contamination. It affects soil by decreasing the availability of essential plant nutrients and increasing the solubility of some toxic metals. The distribution of wet sulphate deposition in eastern North America is shown in Map 6.4.1. The granite-based soils of the Canadian Shield are generally more susceptible to acidification than other soils in Canada.

The nitrogen oxides that contribute to acid precipitation are part of a larger human-induced increase in global nitrogen availability.[3] The agricultural use of nitrogen fertilizers, the large-scale growth of soybeans and other nitrogen-fixing crops, and the release of nitrogen compounds associated with fossil fuel combustion have contributed to a significant increase in the global nitrogen cycle.[4] This has led to negative environmental impacts, even though nitrogen is an essential and natural component in soils.[5]

Text Box 6.4.1
Petroleum and Polycyclic Aromatic Hydrocarbons

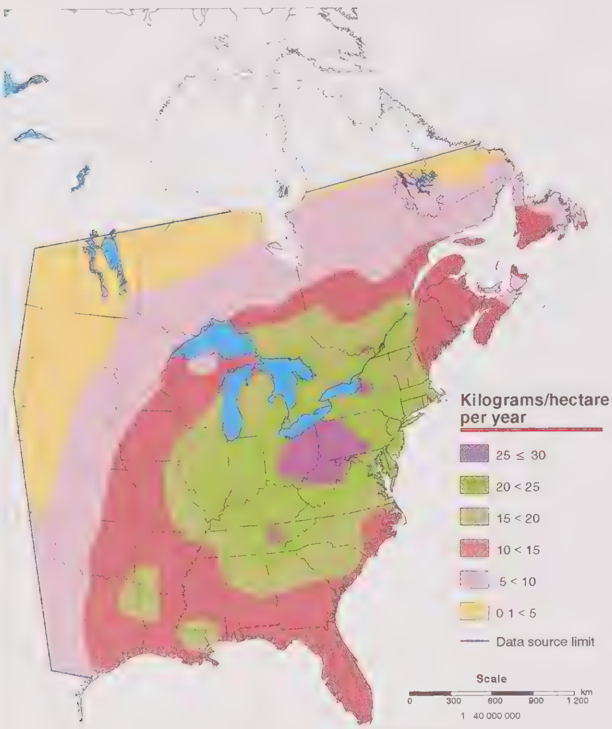
The transport and use of fossil fuels have resulted in the environmental release of numerous petroleum products. Oil spills are the most obvious example of the release, but urban run-off, wastewater and motorized aquatic vehicles are significant sources.[1] Oil and other petroleum products accounted for 58% of the total number of spills reported to Environment Canada's Environmental Emergencies Program between 1984 and 1995.[2]

Accumulation of petroleum products in most terrestrial organisms is limited since hydrocarbons can generally be metabolized and excreted.[3] Plants do not appear to absorb petroleum hydrocarbons from soil because these molecules tend to cling to soil organic matter. Their roots are susceptible to smothering, however, and they may also be sensitive to the secondary impacts of contamination, including changes in acidity and the depletion of soil nitrogen and oxygen.[4]

1. Hoffman, D.J., A.R. Barnett, G.A. Burton Jr. and J. Cairns Jr. (eds.), 1996, *Handbook of Ecotoxicology*, CRC Press, Boca Raton.
2. Environment Canada, 1998, *Summary of Spill Events in Canada, 1984-1995*, Catalogue No. En49-14/5-3E, Ottawa.
3. These contaminants are not treated in section 6.5–**Contaminants in biota** because they do not usually accumulate in organisms.
4. Hoffman *et al., op cit.*

1. Wall, G.J. *et al.*, 1995, "Erosion," in D.F. Acton and L.J. Gregorich (eds.), *The Health of Our Soils: Toward Sustainable Agriculture in Canada*, Centre for Land and Biological Resources Research, Agriculture and Agri-Food Canada, Catalogue No. A53-1906/1995E, pp. 61–76, Ottawa.
2. Gregorich, E.G. *et al.*, 1995, "Changes in Soil Organic Matter," in D.F. Acton and L.J. Gregorich (eds.), *The Health of Our Soils: Toward Sustainable Agriculture in Canada*, Centre for Land and Biological Resources Research, Agriculture and Agri-Food Canada, Catalogue No. A53-1906/1995E, pp. 41–50, Ottawa.
3. Nitrogen enrichment is treated here because of its immense scale and its relation to fossil fuel combustion; it may also be considered a local contaminant when fertilizers are applied in excess on agricultural fields.
4. Vitousek, P.M., H.A. Mooney, J. Lubchenco and J.M. Melillo, 1997, "Human Domination of Earth's Ecosystems," *Science*, Vol. 277, July 25, pp. 494–499.
5. Examples of these negative impacts include nitrate contamination of groundwater and eutrophication of water bodies. See section 6.3–**Water quality** for more details.

Map 6.4.1
Average Wet Sulphate Deposition in Eastern North America, 1991-1995



Source:
Air Quality Measurements and Analysis Research Division, Atmospheric Environment Service, Environment Canada, Downsview, Ontario.

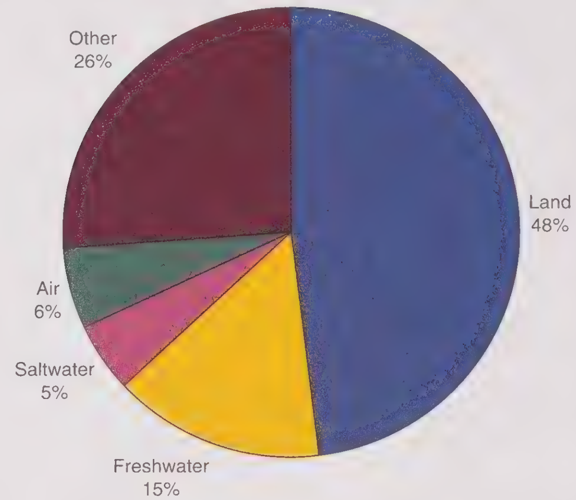
A recent Statistics Canada survey[1] suggests that agricultural operators are generally careful with their use of nitrogen and other fertilizers. It found that, in 1995, 72% of the farms that grew crops applied commercial fertilizers. Of this group, application decisions for almost two-thirds of farms were based on some form of nutrient testing—63% used soil tests and 2% tested foliage. Furthermore, 83% of the farms that applied manure and 82% of those using green manures reduced the amount of commercial fertilizers applied to offset the nutrient content in the manure.

Local contamination

Industrial spills are perhaps the most obvious form of local contamination. Accidents can occur during the transport, manufacture, storage, disposal or treatment of goods. Environment Canada, through its Environmental Emergencies Program, collects and compiles spill data in the National Analysis of Trends in Emergencies System (NATES) database. Land is the medium most frequently

1. Statistics Canada, 1996, *Farm Inputs Management Survey, 1995*, Catalogue No. 21F0009XPE, Ottawa.

Figure 6.4.1
Distribution of Media Affected by Spills, 1984-1995



Note:
'Other' includes spills that have an impact on two or more environmental media.
Source:
Environment Canada, 1998, *Summary of Spill Events in Canada, 1984-1995*, Catalogue No. En49-14/5-3E, Ottawa.

affected by these accidental releases (Figure 6.4.1), but this does not necessarily translate into the largest environmental impact.[2]

Not all industrial pollutant releases are accidental; many result from normal manufacturing operations. The National Pollutant Release Inventory (NPRI) attempts to measure the volume of these releases in addition to accidental spills (see section 6.1–**Waste generation and management**). In 1996, 1 818 facilities reported their on-site emissions and off-site transfers of nearly 180 pollutants to the NPRI.[3] On-site releases to land represented 9.7% (13 890 tonnes) of the total volume of releases documented in the NPRI; an additional 12.5% (17 821 tonnes) was disposed of by underground injection.[4] Air is the primary medium polluted by the releases reported to the NPRI, receiving 68.6% of all industrial releases.[5] The top five on-site releases to land by weight are outlined in Table 6.4.5. Metals are the dominant pollutants with the exception of ethylene glycol, which is used to remove ice from aircraft.

2. Environment Canada, 1998, *Summary of Spill Events in Canada, 1984–1995*, Catalogue No. En49-14/5-3E, Ottawa.
3. There are 176 substances that must be reported under the NPRI. For more information, see <http://www.ec.gc.ca/pdb/npri/>.
4. These figures are subject to change as the NPRI database is continually updated. The data in this report reflect a database extraction conducted on February 1, 1999.
5. Note that this appears to contradict Figure 6.4.1. The distinction is that spill events are represented in the figure, while the NPRI percentages are based on the volume, not the number of releases.

Table 6.4.5
Top Five On-site Releases to Land, 1996

Substance	Releases	As share of total
	tonnes	percent
Zinc and its compounds	4 989.7	35.9
Ethylene glycol	3 209.8	23.1
Manganese and its compounds	1 910.2	13.8
Lead and its compounds	894.3	6.4
Asbestos (friable form)	848.2	6.1

Source:
Environment Canada, Pollution Data Branch, National Pollutant Release Inventory Database, <http://www.ec.gc.ca/pdb/npri/>, (accessed February 1, 1999).

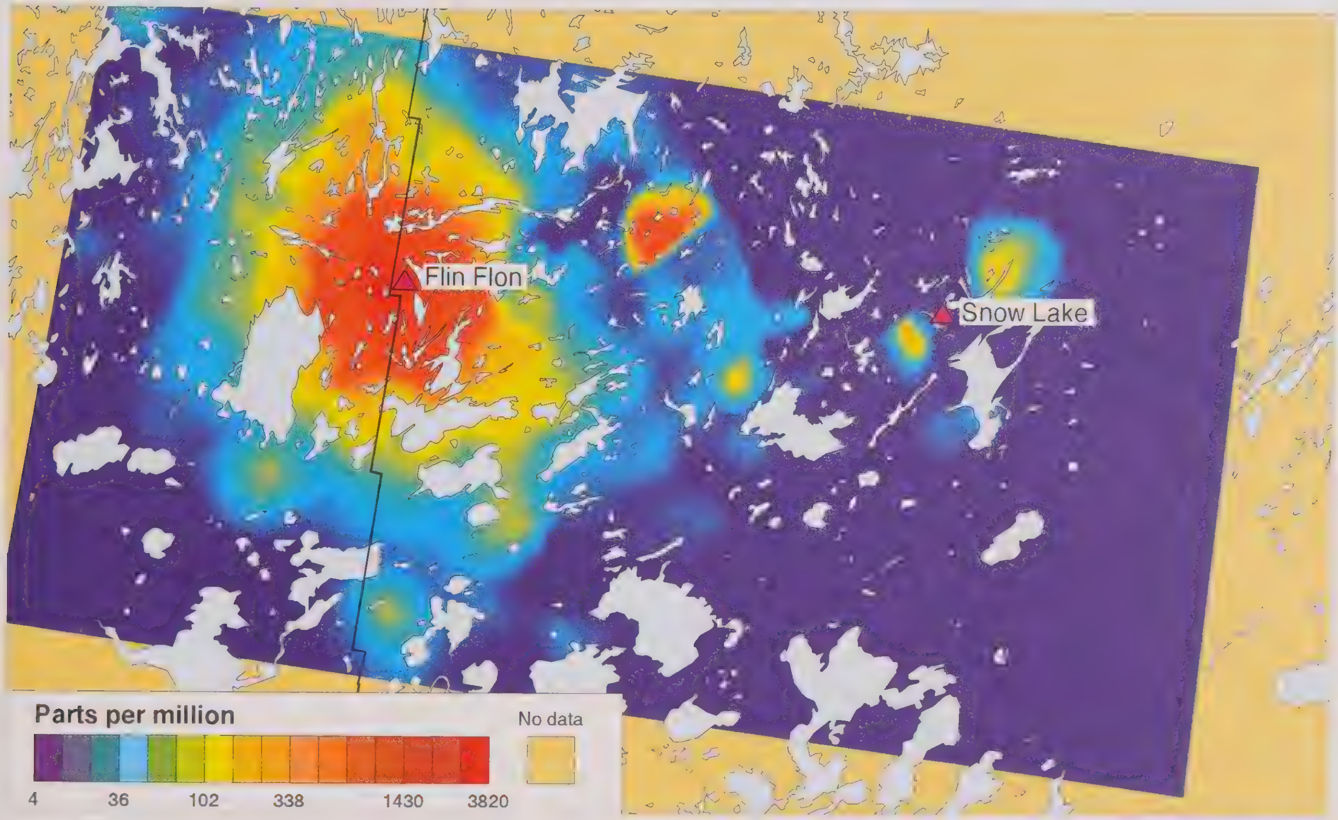
A study of heavy metal deposition around the base metal smelting complex in Flin Flon, Manitoba, reveals the extent to which industrial sources of contamination can influence soil composition.[1] This study found that within 70 to 104 kilometres of the smelter site, the major smelter metals were in excess of natural background concentrations (Map 6.4.2). New technology in the smelter process has decreased total metal releases from 6 834 tonnes per year in 1974 to 632 tonnes per year in 1995. This smelter has been in operation since 1930, however, and a significant reservoir of contaminants remains from historical activity. It is important to note that many locations in Canada have naturally high levels of heavy metals, making it difficult to determine the extent to which human activity has elevated their concentration.

Industry is not the only source of soil contaminants (Text Box 6.4.2). Agricultural soil amendments, for example, may contain heavy metal residues in addition to the nutrients they supply (Table 6.4.6). Many soil amendments are, in fact, mined from geological deposits that naturally contain heavy metals. Cadmium is the main metal of concern because it is toxic and can readily accumulate in plant tissues.[2]

1. McMartin, I., P.J. Henderson and E. Nielsen, 1999, "Impact of a Base Metal Smelter on the Geochemistry of Soils in the Flin Flon Region, Manitoba and Saskatchewan," *Canadian Journal of Earth Sciences*, Vol. 36, p. 141–160.

2. Webber, M.D. and S.S. Singh, 1995, "Contamination of Agricultural Soils," in D.F. Acton and L.J. Gregorich (eds.), *The Health of Our Soils: Toward Sustainable Agriculture in Canada*, Centre for Land and Biological Resources Research, Agriculture and Agri-Food Canada, Catalogue No. A53-1906/1995E, pp. 87–96, Ottawa.

Map 6.4.2
Copper Deposition Around the Flin Flon Base Metals Smelter Complex, Manitoba and Saskatchewan, 1992-1995



Source:
McMartin, I., P.J. Henderson and E. Nielsen, 1999, "Impact of a Base Metal Smelter on the Geochemistry of Soils in the Flin Flon Region, Manitoba and Saskatchewan," *Canadian Journal of Earth Sciences*, Vol. 36, p. 141-160

Table 6.4.6
Heavy Metal Concentrations in Various Soil Amendments

Amendment	Cadmium	Cobalt	Chromium	Copper	Nickel	Lead	Zinc
	dry weight concentration (parts per million)						
Triple superphosphate	9	5	92	3	36	3	108
Urea	<0.1	<1	<3	<0.4	<1	<3	<1
Potassium chloride	<0.1	2	<3	<0.6	4	3	<1
Agricultural lime	<0.1	<1	<3	<0.2	5	<3	<2
Cow manure	1	6	56	62	29	16	71
Sewage sludge	5	5	350	660	35	90	800

Source:
Webber, M.D. and S.S. Singh, 1995, "Contamination of Agricultural Soils," in D.F. Acton and L.J. Gregorich (eds.), *The Health of Our Soils: Toward Sustainable Agriculture in Canada*, Centre for Land and Biological Resources Research, Agriculture and Agri-Food Canada, Catalogue No. A53-1906/1995E, pp. 87-96, Ottawa.

Text Box 6.4.2
Wetlands and Lead Shot

An unusual form of local pollution occurs in wetlands, where lead shot used for hunting remains in the ecosystem for long periods after its use. The contamination is not confined to the soil, as shot pellets are easily ingested by waterfowl, leading to poisoning and death. The problem was significant enough to warrant 1997 legislation aimed at reducing the use of lead shot. A 1995 estimate suggested that approximately 2 000 tonnes of lead were entering the environment yearly through hunting activities in Canada.[1]

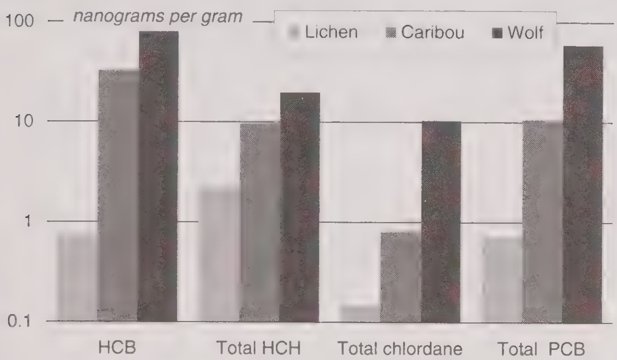
1. Schuenhammer, A.M. and S.L Norris, 1995, *A Review of the Environmental Impacts of Lead Shotshell Ammunition and Lead Fishing Weights in Canada*, Environment Canada, Occasional Paper No. 88, Catalogue No. CW69-1/88E, Canadian Wildlife Service, Ottawa.

6.5 Contaminants in biota[1]

Thousands of contaminants are present in the Canadian environment. Although levels of these substances in air, water and soil may be very low or even immeasurable, some of them are found in much higher concentrations in the tissues of individual organisms. This is due to a process called bioaccumulation, and is the result of a gradual accumulation of contaminants in the tissues of plants and animals. Some contaminants are also passed along the food chain from one organism to the next; this is biomagnification, and it can result in contaminant loads in top predators several million times higher than in the surrounding environment (Figure 6.5.1).[2] Levels of contaminants in plants and animals can thus provide a more reliable measure of biotic influence than levels in air, water or soil alone.

Bioaccumulation and biomagnification have important human health implications. Many of the animal-based foods commonly consumed by humans are high in fat, and fatty tissues are where many contaminants tend to accumulate. This is particularly worrisome in communities where individuals consume high quantities of fish and game.

Figure 6.5.1
Biomagnification in an Arctic Food Web, Bathurst Herd, N.W.T., 1992-1994



Source:
Elkin, B.T., 1996, "Organochlorine, Heavy Metal and Radionuclide Contaminant Transfer Through the Lichen-Caribou-Wolf Food Chain," in J.L. Murray, R.G. Shearer and S.L. Han (eds.), *Environmental Studies No. 73. Synopsis of Research Conducted Under the 1994/95 Northern Contaminants Program,* pp. 247-252, Catalogue No. R71-19/73-1995E, Department of Indian Affairs and Northern Development, Ottawa.

1. The primary reference for this section is: Hoffman, D.J., B.A. Rattner, G.A. Burton Jr. and J. Cairns Jr. (eds.), 1995, *Handbook of Ecotoxicology,* CRC Press, Boca Raton.
2. This level of biomagnification is found in complex food webs, where there are several levels of carnivores. Simple food chains like the one shown in Figure 6.5.1 do not lead to such high magnifications.

Contaminants can have either acute or chronic health effects. Acute effects are those that quickly cause illness or death in exposed organisms. Chronic effects are subtler; they are not immediately lethal, but can lead to long-term health problems. These include compromised immune systems, derailed prenatal and postnatal development, reproductive failure, behavioural abnormalities and cancer. Some of these sublethal effects are thought to be the result of the hormone-mimicking nature of certain contaminants (Text Box 6.5.1).

Text Box 6.5.1
Endocrine Disrupters

The endocrine system consists of glands that produce and respond to hormones carried in the blood. It regulates processes from metabolism to growth, sexual development and reproduction.

The discovery that several contaminants can mimic human hormones has led to considerable concern and research. These endocrine disrupters have been linked to developmental and behavioural abnormalities, reproductive impacts and damage to the immune system in wildlife and humans.

Synthetic chemicals can both mimic and block the action of hormones. Dioxins, furans, PCBs and DDT are among several environmental contaminants that cause a hormone-like response in organisms. The organochlorine pesticide DDT, for example, acts like a weak version of the hormone estrogen.

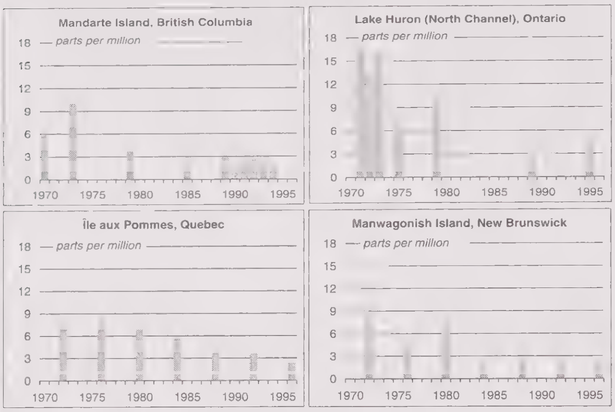
Several naturally occurring plant substances also mimic hormones. Whereas these compounds (called phytoestrogens) can be broken down by organisms, the synthetic contaminants can persist in animal tissues for long periods.

Unlike other chemical pathways that differ widely between species, the endocrine system shows remarkable similarity in different organisms. All vertebrates share the same basic endocrine system, and hence can be expected to respond to hormone disruption in a similar fashion. The health impacts observed in wild animal populations are thus possible sentinels of human health impacts.

Researchers have not yet found a definitive link between human health problems and environmental exposure to synthetic endocrine disrupters. This is because the general population is exposed to very low doses and because of numerous confounding health influences (see section 6.6–**Human health**).

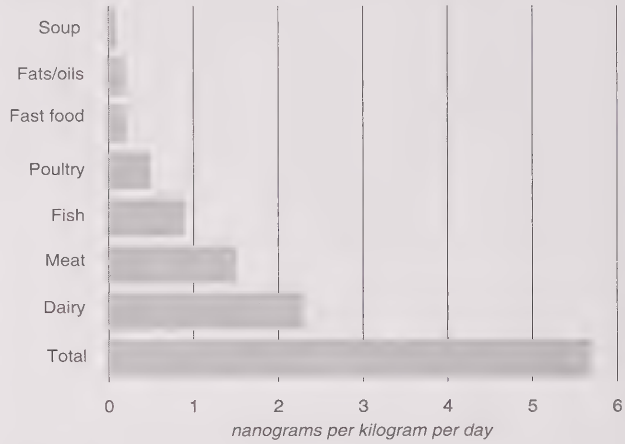
Source:
Colborn, T., D. Dumanoski and J.P. Myers, 1996, *Our Stolen Future—Are We Threatening Our Fertility, Intelligence, and Survival? A Scientific Detective Story,* Dutton, New York.

Figure 6.5.2
PCB Concentrations in Double-Crested Cormorant Eggs, 1970-1996



Source:
Environment Canada, Canadian Wildlife Service.

Figure 6.5.3
Daily PCB Intake per Kilogram of Body Weight From Various Food Sources, 1992-1996



Source:
Newsome, W.H., D.J. Davies and W.F. Sun, 1998, "Residues of Polychlorinated Biphenyls (PCB) in Fatty Foods of the Canadian Diet," *Food Additives and Contaminants*, Vol. 15, No. 1, pp. 19-29.

6.5.1 Organochlorines

Chlorinated organic compounds (organochlorines) are persistent contaminants, meaning they resist both biological and geochemical breakdown. Many of them can affect health once they enter an organism. Even though many of these substances have been banned in Canada, they continue to enter our environment through atmospheric deposition from other countries, leaking landfill sites, ocean currents, migratory species and the disturbance of contaminated sediments. Text Box 6.5.2 outlines the main organochlorine contaminants.

PCBs

Polychlorinated biphenyls (PCBs) form a large family of chemical compounds. They are commonly known for their use as insulators in electrical equipment.

Wildlife is primarily exposed to PCBs through aquatic food webs. Aquatic organisms accumulate PCBs from water and sediments in their fatty tissues. Animals farther up the food web consume these organisms, leading to biomagnification of the PCBs—hence the use of fish-eating birds like herring gulls and double-crested cormorants to indicate the environmental presence of PCBs. PCB levels have been declining in double-crested cormorant eggs across Canada since reaching their peak in the 1970s (Figure 6.5.2).

Canadians receive most of their PCB exposure through fatty foods, including fish, meat and dairy products (Figure 6.5.3). The provisional tolerable daily intake for PCBs in Canada is currently 1.0 micrograms per kilogram of body weight.[1] This is well above the observed exposure of 0.0057 micrograms found in the study illustrated in Figure 6.5.3.

Dioxins and furans

Dioxins and furans are the common names of polychlorinated dibenzo-p-dioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs). They enter the environment through industrial releases, seepage from landfill sites and atmospheric deposition.

Like PCBs, dioxins and furans form a large family of compounds. These chemicals are not equally toxic. The molecules of primary concern are 2,3,7,8-TCDD (tetrachlorodibenzodioxin) and 2,3,7,8-TCDF (tetrachlorodibenzofuran).[2] Levels of dioxins and furans in double-crested cormorant eggs across Canada are illustrated in Figure 6.5.4.

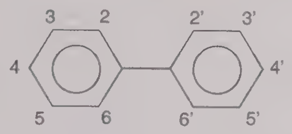
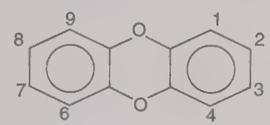
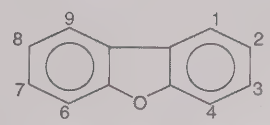
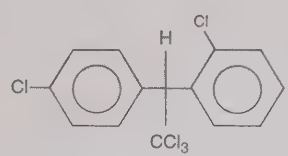
Humans are exposed to dioxin mainly through food, particularly fish and milk. Fish consumption guidelines are expressed in parts per trillion, indicating the high toxicity of these compounds.

Pesticides

Pesticides become problematic when they affect unintended, non-target species or when they have unexpected effects on ecosystems. Organochlorine pesticides are of particular concern, as they are generally very

1. The tolerable daily intakes for the contaminants in this section were provided by J. Salminen, Chemical Health Hazard Assessment Division, Health Canada, and reflect recommendations as of July 1998.
2. 2,3,7,8-TCDD is used as the standard against which the toxicity of other dioxins, furans and PCB molecules is expressed. Mixtures of these compounds can be expressed in terms of TEQs (toxic equivalents), relative to the toxicity of 2,3,7,8-TCDD.

Text Box 6.5.2
Source, Uses and Biological Effects of Selected Organochlorine Compounds

Compound	Chemical structure	Source/Uses	Biological effects
Polychlorinated biphenyls (PCBs)		commercial manufacture began in 1929; 209 possible molecules, each called a PCB congener; used in electrical equipment (most notably transformers) and as flame retardants, in lubricants and in paints, to name a few applications; most uses banned in 1977 but still present in older electrical equipment, notably fluorescent light ballasts and electrical transformers	acute toxicity observed in both laboratory animals and wildlife; have been linked to cancer in rats and monkeys, behavioural changes in wildlife, and reproductive impacts in laboratory animals and wildlife; humans and several bird species appear able to survive higher exposures than many laboratory-studied organisms
Dioxins and furans	 Dioxin  Furan	75 different dioxin and 135 furan molecules are possible; unintended by-products of a number of industrial activities, including PCB manufacture, pulp and paper production, and polyvinyl chloride (PVC) manufacture and incineration; also produced by waste incineration, fossil fuel combustion, firewood burning and forest fires; although natural dioxin and furan production is possible, human activity is the largest source of these compounds	acutely toxic to some organisms, the most sensitive being guinea pigs, mink, poultry and nonhuman primates; have also been associated with reproductive and developmental impacts on laboratory animals and wildlife; have been linked to cancer in laboratory animals
Pesticides	 DDT	DDT (dichlorodiphenyltrichloroethane) is the best known of the organochlorine pesticides; first synthesized in 1874, but insecticidal properties were not discovered until 1939; registered in Canada in 1946 and became widely used as an insecticide; residues of DDE (dichlorodiphenyldichloroethylene, a metabolite of DDT) discovered in peregrine falcon eggs in California as early as 1948; concerns about impact on wildlife mounted in the 1960s, leading to use restrictions in 1969 and eventual withdrawal of registration in 1985; still used in many countries, particularly for control of malaria-carrying mosquitoes	in addition to acute toxicity, organochlorine pesticides exhibit sub-lethal effects on wildlife, the most notorious being eggshell thinning; have also been linked to endocrine mimicry (Text Box 6.5.1)

Note:
Numbers on the PCB, dioxin and furan chemical structures are used to describe the position of chlorine atoms. Thus, 2,3,7,8-tetrachlorodibenzodioxin is a dioxin molecule with four chlorine atoms found at the positions 2,3,7 and 8.
Sources:
Environment Canada, 1993, *Environmental Indicator Bulletin: Toxic Contaminants in the Environment, Persistent Organochlorines*, Catalogue No. En 1-19/92-1E, Ottawa.
Hoffman, D.J., B.A. Rattner, G.A. Burton Jr. and J. Cairns Jr. (eds.), 1995, *Handbook of Ecotoxicology*, CRC Press, Boca Raton.

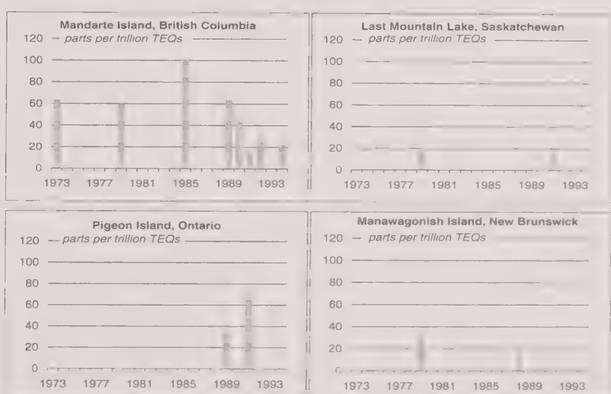
toxic and often environmentally persistent; some also bioaccumulate and biomagnify through food webs. Persistent, toxic organochlorine pesticides include DDT, mirex, hexachloro-cyclohexane (HCH), hexachlorobenzene (HCB), toxaphene, chlordane and dieldrin. As shown in Figure 6.5.5, several of these contaminants are present in the breast milk of Canadian women. Humans are exposed to these contaminants through residues in foods.

DDE, a metabolite or breakdown product of DDT, has declined in double-crested cormorant eggs from its highest levels in the early 1970s (Figure 6.5.6).

6.5.2 Heavy metals

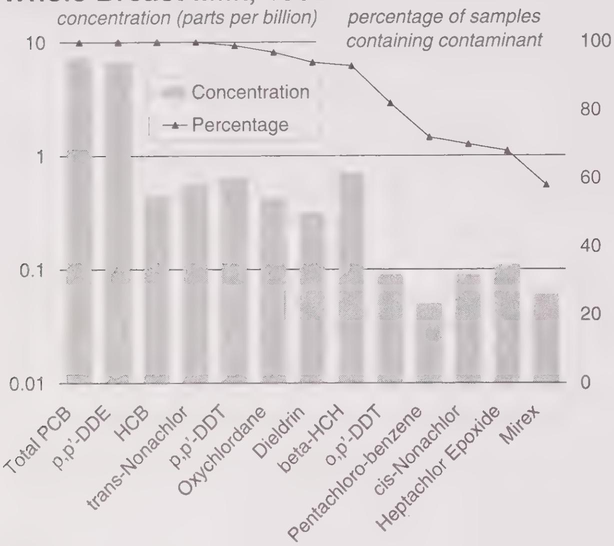
There are several naturally occurring metals whose presence in the environment has been increased by human activity. Mercury, lead and cadmium are particularly important examples because of their high toxicity.

Figure 6.5.4
Dioxin and Furan Concentrations in Double-Crested Cormorant Eggs, 1973-1994



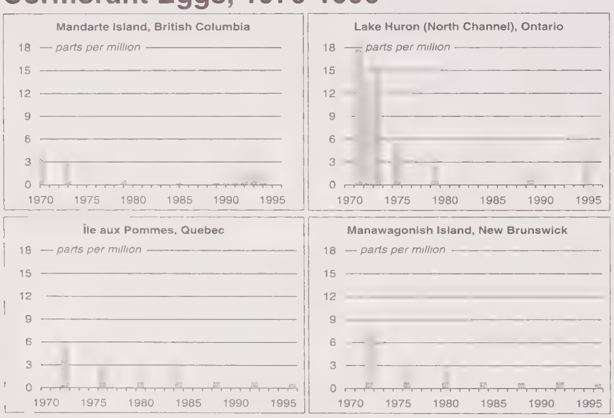
Source:
Environment Canada, Canadian Wildlife Service.

Figure 6.5.5
Occurrence of Selected Contaminants in Whole Breast Milk, 1992



Source:
Newsome, W.H., D. Davies and J. Doucet, 1995, "PCB and Organochlorine Pesticides in Canadian Human Milk—1992," *Chemosphere*, Vol. 30, No. 11, pp. 2143-2153.

Figure 6.5.6
DDE Concentration in Double-Crested Cormorant Eggs, 1970-1996

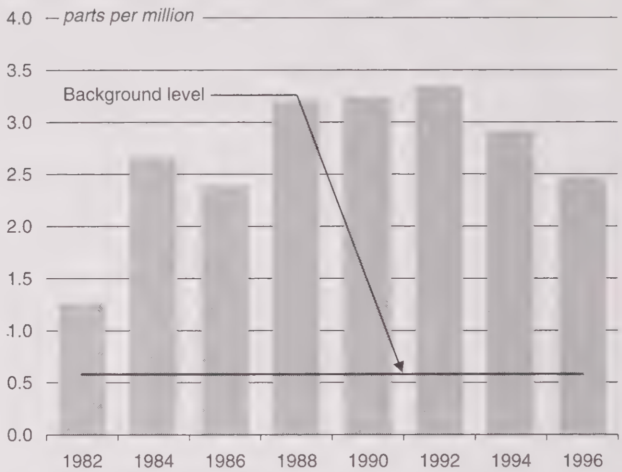


Source:
Environment Canada, Canadian Wildlife Service.

Mercury (Hg)

Mercury is released from industrial processes and fossil fuel combustion; it has also been used as a seed treatment. It is carried into ecosystems by both air and water. Mercury is not readily absorbed by organisms, but when bacteria convert it into methylmercury (a process called methylation) it becomes easier to absorb and more toxic. Newly flooded reservoirs and acidic water bodies stimulate the formation of methylmercury (CH_3Hg), leading to mercury levels in

Figure 6.5.7
Mean Mercury Concentrations in 70-centimetre Pike From the Robert-Bourassa Reservoir, Northern Quebec, 1982-1996



Source:
Doyon, J.F. and A. Tremblay, 1997, *Réseau de suivi environnemental du complexe La Grande, Phase 1 (1996). Évolution des teneurs en mercure et études complémentaires (secteur ouest).* Rapport conjoint présenté par Hydro-Québec, Service hydraulique et environnement, Direction expertise et support technique en production et le Groupe-conseil Génivar inc.

excess of natural background concentrations (Figure 6.5.7).

Methylmercury both bioaccumulates and biomagnifies in aquatic ecosystems and is stored in the liver, kidneys and muscle of affected organisms. Chronic exposure leads to brain and kidney damage. Methylmercury can be absorbed directly from water, food and air.

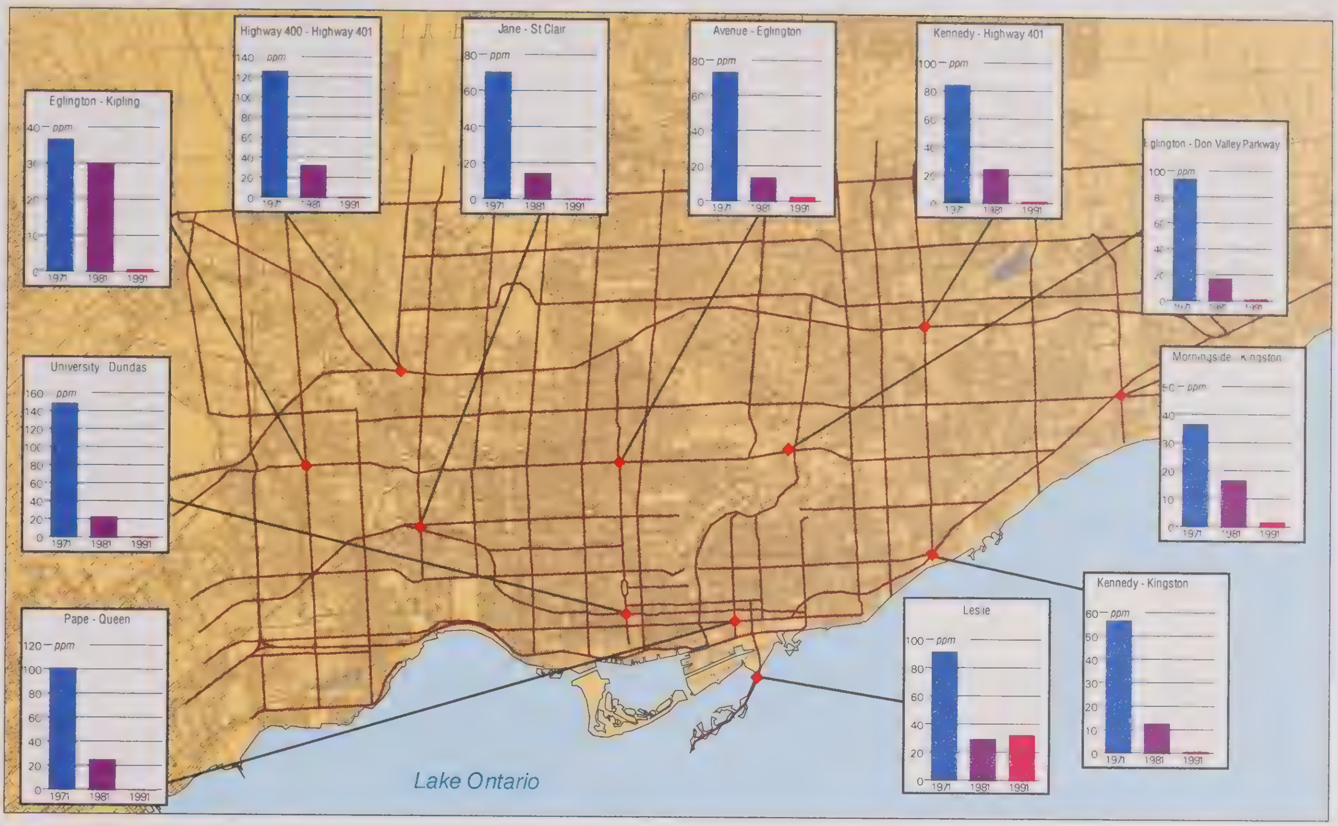
The main environmental sources of human exposure to mercury are fish, shellfish and game. The provisional tolerable daily intake for methylmercury is 0.47 micrograms per kilogram of body weight, although it has been suggested that this limit be lowered to 0.2 micrograms for children and women of childbearing age.[1]

Lead (Pb)

The use of lead in motor fuel additives, batteries and paints has resulted in a wide environmental distribution. Lead is also released as a by-product of many industrial activities, including mining, smelting and fossil fuel combustion. An important local source in wetlands is lead shot (see Text Box 6.4.2 in section 6.4–**Soil**). Natural releases come from volcanic eruption, forest fires and weathering. Lead levels on Toronto street tree foliage have been declining since the phase-out of leaded gasoline in the 1970s (Map 6.5.1).

1. J. Salminen, Chemical Health Hazard Assessment Division, Health Canada, personal communication.

Map 6.5.1
Lead Levels in Toronto Street Tree Foliage



Source:
Metro Toronto lead study, 1971-1991, Draft, Ontario Ministry of Environment, personal communication.

The toxicity of lead has been recognized for centuries. Its primary impacts are on the neurological development of children, nervous system and blood. Once lead enters an organism it accumulates in bones and other tissues. Although it is subject to some bioaccumulation, lead does not biomagnify in food webs. The tolerable intake set by the World Health Organization is 25 milligrams per kilogram of body weight per week.

Cadmium (Cd)

Cadmium enters the environment from zinc and lead production, fossil fuel combustion, paints, plastics, batteries, waste incineration and weathering of rock. Like lead, cadmium accumulates in organisms but does not biomagnify through food webs. Cadmium tends to concentrate in the liver and kidneys, potentially leading to kidney disorders, bone decalcification, anemia, cardiovascular disease and cancer.

Water, air and food are sources of cadmium exposure; tobacco smoke is also a significant source. The recommended tolerable daily intake is 1.0 milligrams per kilogram of body weight.

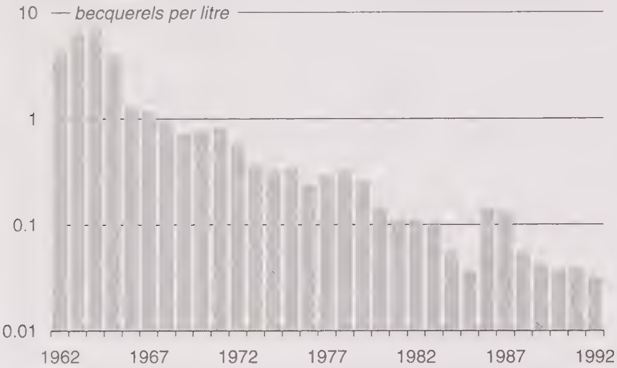
6.5.3 Radionuclides

Plants and animals are exposed to radiation from several sources: cosmic gamma radiation, radon gas, naturally occurring lead-210 and polonium-210, uranium in water and soils, and cesium-137 and strontium-90 from atmospheric nuclear weapons testing.

The health effects of radionuclides are connected to the dose received, which depends on the type of radiation—alpha (α), beta (β) or gamma (γ)—and the amount and duration of exposure. Radioactivity is measured in becquerels (Bq), or atomic disintegrations per second, while doses are measured in millisieverts (mSv). Table 6.5.1 lists several radiation doses and their associated cancer risk.

Anthropogenic releases of radionuclides peaked in the 1960s. After atmospheric weapons testing was limited, levels of cesium-137 in cow's milk declined more or less steadily until the Chernobyl nuclear disaster in 1986 (Figure 6.5.8).

Figure 6.5.8
Cesium-137 Radioactivity in Cow's Milk, 1962-1992



Source:
Health Canada, Radiation Protection Bureau, Environmental Radiation Hazards Division.

Table 6.5.1
Radiation Doses

Dose	Comments	Cancer risk
millisieverts		
0.1	return transatlantic flight; dental or chest X-ray	1 in 200 000
1	average natural yearly dose (excluding radon)	1 in 20 000
20	highest allowable yearly dose for workers exposed to radiation	1 in 1000
1 000	acute effects after short exposure	1 in 20
10 000	death after short exposure	-

Sources:
Arctic Monitoring and Assessment Programme, 1997, *Arctic Pollution Issues: A State of the Arctic Environment Report*, p. 112, AMAP, Oslo.
Department of Indian Affairs and Northern Development, Northern Contaminants Program, 1997, *Canadian Arctic Contaminants Assessment Report*, p. 338, Catalogue No. R72-260/1997E, Ottawa.

6.6 Human health

The causes of morbidity and mortality in Canada have changed considerably in the last century. Traditional causes such as unsafe water and poor sanitation have been eclipsed by poor diet, smoking, environmental pollutants and lack of exercise. Infectious diseases like tuberculosis have diminished in importance, while cardiovascular disease and cancer have become more significant (Table 6.6.1).

Sorting out the factors influencing human health is difficult. The interaction of social influences and individual health behaviours can be far more significant than passive exposure to physical or biological disease-causing agents.

Table 6.6.1
Major Causes of Death, 1926 and 1996

Cause of death	1926	1996
	percent of deaths	
Cardiovascular diseases	19.0	37.0
Cancer	7.0	28.0
Respiratory diseases	15.0	9.0
Accidents/violence	5.0	6.0
Infectious diseases	12.0	1.5
Perinatal causes	9.0	0.5
All other causes	32.0	18.0

Sources:
Brancker, A., D.A. Enarson, S. Grzybowski, E.S. Hershfield and C.W.L. Jeanes, 1992, "A Statistical Chronicle of Tuberculosis in Canada: Part 1. From the Era of Sanatorium Treatment to the Present," *Health Reports*, Catalogue No. 82-003-XPB, Vol. 4, No. 2, pp. 103-112, Ottawa.
Statistics Canada, Health Statistics Division.

Cancer, respiratory and cardiovascular disease

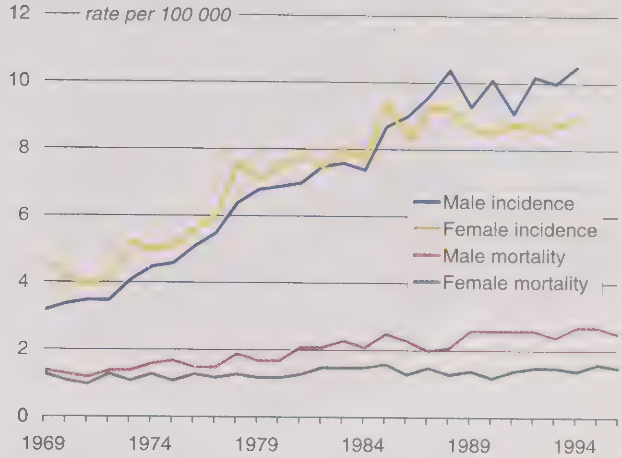
The environment can have an impact on health in a number of ways: temperature extremes may cause heat stress or hypothermia; air pollution can aggravate respiratory conditions; and exposure to ionizing radiation may lead to certain forms of cancer.

Human activity can contribute to environment-related illness by increasing pollution, through altered ecosystems or climatic processes, and through personal behaviours that increase our exposure to disease-causing agents. Melanoma, certain other cancers and respiratory illness all have a link to the environment.

Melanoma

Melanoma skin cancer incidence and mortality have levelled off in recent years, after increasing since the 1960s (Figure 6.6.1).[1] According to the Institute of Health Promotion Research, the risks for melanoma skin cancer include sunburns in early childhood, accumulated sun exposure, having many moles, and atmospheric ozone depletion.[2]

Figure 6.6.1
Melanoma Incidence and Mortality, 1969-1995



Note:
Incidence data end in 1994; mortality data end in 1996.
Sources:
National Cancer Institute of Canada, 1998, *Canadian Cancer Statistics 1998*, Toronto.
National Cancer Institute of Canada, *Canadian Cancer Statistics 1999*, <http://www.cancer.ca/stats>, (accessed April 9, 1999).

Table 6.6.2
Prevalence of Sun Avoidance, 1996

Type of protection	Outdoor workers	People at leisure
	percent	
Using sunscreen on body	66	48
Using sunscreen on face	62	47
Avoiding sun	55	34
Seeking shade	45	28
Wearing sunglasses	43	30
Wearing hat	30	41
Wearing protective clothes	22	33

Source:
Lovato, C., J. Shoveller and J. Rivers (eds.), 1998, *1996 National Survey on Sun Exposure and Protective Behaviours*, Institute of Health Promotion Research, University of British Columbia.

The percentages of Canadians estimated to take various forms of precaution when exposed to sunlight are outlined in Table 6.6.2.

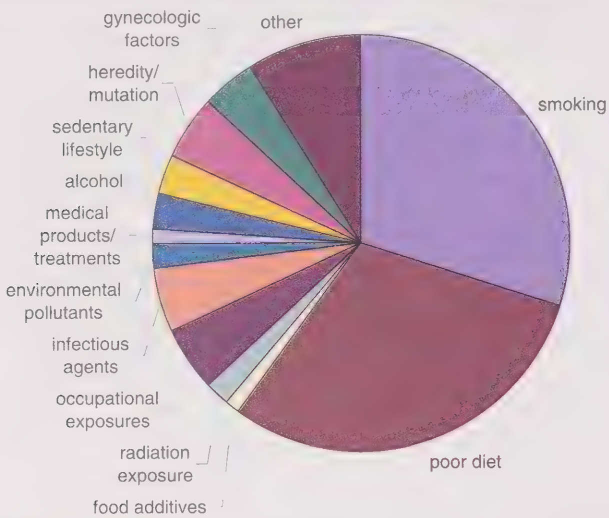
Other cancers

Estimates of the causes of cancer deaths suggest that the environment plays a small role compared to diet and smoking (Figure 6.6.2). The effects of very low doses of some environmental pollutants have, however, come to the fore in recent years with the discovery of the hormone-mimicking action of these compounds. This issue is discussed in more detail in section 6.5–**Contaminants in biota**.

1. Gaudette, L.A. and R. Gao, 1998, "Changing Trends in Melanoma Incidence and Mortality," *Health Reports*, Statistics Canada, Catalogue No. 82-003-XPB, Vol. 10, No. 2, pp. 29–41, Ottawa.

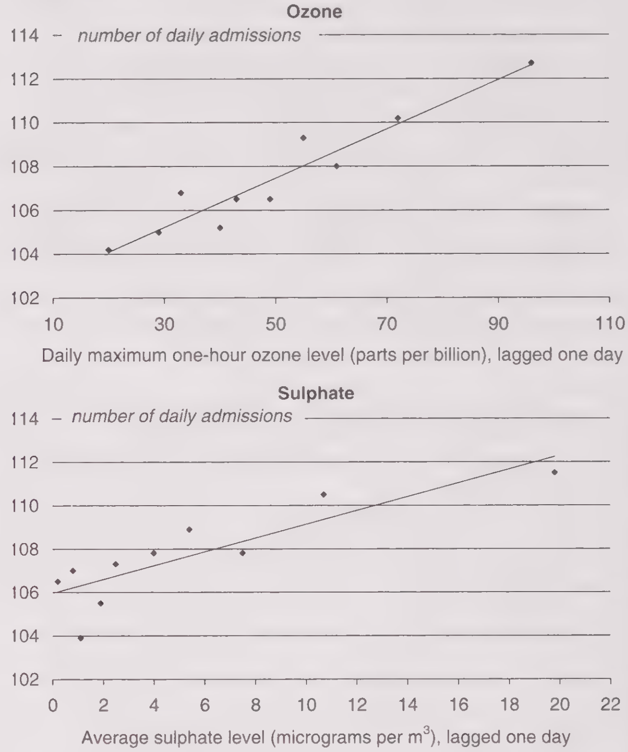
2. Lovato, C., J. Shoveller and J. Rivers (eds.), 1998, *1996 National Survey on Sun Exposure and Protective Behaviours*, Institute of Health Promotion Research, University of British Columbia.

Figure 6.6.2
Estimated Causes of Fatal Cancer Cases



Note:
This chart is presented to illustrate the importance of lifestyle and social factors in cancer incidence. Cancer is a complex illness, and these estimates of causation represent the relative importance of the determinants of cancer. Note that 'environmental pollutants' in the figure is a subset of the total of the environmental determinants, which also includes occupational exposures, food additives, radiation and infectious agents.
Source:
Adapted from Trichopoulos, D., F.P. Li and D.J. Hunter, 1996, "What Causes Cancer?" *Scientific American*, September, pp. 80-87.

Figure 6.6.3
Impact of Air Pollution on Respiratory Admissions[1] to Selected Ontario Hospitals, 1983-1988



Note:
1. Hospital admissions occurring one day after exposure.
Source:
Burnett, R.T. *et al.*, 1994, "Effects of Low Ambient Levels of Ozone and Sulphates on the Frequency of Respiratory Admissions to Ontario Hospitals," *Environmental Research*, Vol. 65, pp. 172-194.

Respiratory and cardiovascular illness

Lung infections, asthma, bronchitis, emphysema and some types of heart disease can all be influenced by exposure to airborne pollution. Although air pollution may not be directly responsible for causing these illnesses, it can have a significant health impact by aggravating existing conditions (Figure 6.6.3). Table 6.6.3 outlines the main outdoor air pollutants associated with cardio-respiratory symptoms.

Table 6.6.3
Airborne Pollutants Associated with Cardiorespiratory Health Impacts

Pollutant	Source	Effects
Ozone (O_3)	formed when sunlight reacts with nitrogen oxides and organic compounds released by fossil fuel combustion, solvents and other sources	associated with respiratory admissions to hospital; main component of smog
Sulfate (SO_4^{2-})	formed when sulphur dioxide (from fossil fuel combustion) reacts with sunlight	implicated in both cardiac and respiratory symptoms
Airborne particulates	formed through fossil fuel combustion and incineration; category also includes pollen, bacteria, dust and other naturally occurring particles	particulate pollutants are classified by size; those less than 2.5 μ ($PM_{2.5}$) reach deeper into the lungs, possibly causing irritation; larger particles (less than 10 μ PM_{10}) may also cause irritation but are more likely to be filtered out in the nasal passage; may be either solid particles or liquid droplets
Nitrogen dioxide (NO_2)	produced by fossil fuel combustion	largest impact on increased risk of death in recent study of urban ambient air pollution;[1] cardio- respiratory impacts of NO_2 exposure may be due to close association with PM_{10}, since both are released together in vehicle exhaust

Note:
1. R.T. Burnett, S. Cakmak and J.R. Brook, "The Effect of the Urban Ambient Air Pollution Mix on Daily Mortality Rates in 11 Canadian Cities," *Canadian Journal of Public Health*, Vol. 89, N° 3, 1998, pp. 152-156.
Source:
Statistics Canada, Environment Accounts and Statistics Division.

Poor indoor air quality also poses health risks. Tobacco smoke is of particular concern because of its links to heart disease and cancer in non-smokers, and ear infections in children.[1] The Statistics Canada General Social Survey found that 4.5 million Canadians aged 15 and over inhaled another person's cigarette smoke daily in 1995.[2] Other sources of indoor air pollution include pets, furnishings, household products, construction materials, heating and cooking.[3] Air pollutants from these sources are a concern even at low concentrations because of the prolonged exposure of those living in the household environment.[4]

Infectious diseases

Many of the organisms with which we share the globe are capable of causing illness. Viruses, fungi, parasites and bacteria all cause infectious diseases.[5] These organisms have always challenged humans, and in spite of today's medical sophistication, they continue to cause disease and death around the world.

Infectious, or contagious, diseases are those that move from one host to another. In Canada, infectious diseases have diminished in importance, compared with illnesses like cancer and cardiovascular disease (Table 6.6.1). Improved sanitation and medical care protect us from many pathogens, but these pathogens are not in a steady state; they continue to evolve and pose new challenges. Examples include the emergence of multidrug-resistant tuberculosis, antibiotic-resistant bacteria in general, and viruses like HIV (identified in 1983) and Hepatitis C (identified in 1989). Changes in our demographics, travel patterns, medical practices, environment and lifestyles are all aspects of human activity that change our susceptibility to disease.

Antibiotic-resistant bacteria

Bacteria cause diseases in humans, ranging from diarrhea and acne to tuberculosis and bubonic plague. Virulence is rare, however, when one considers the sheer number of bacterial species with which we co-exist quite peacefully. Our bodies are covered with bacteria, both inside and out, and it is only rarely that these cause us any distress.

Antibiotic resistance arises through natural selection when bacteria are exposed to the chemicals designed to kill them. This exposure can occur in humans or livestock undergoing antibiotic therapy (Text Box 6.6.1), in households where antibiotic cleaning products are frequently used, or in the environment when antibiotics are applied to crops in fields or to fish in bodies of water.

The rise of penicillin resistance in *Streptococcus pneumoniae* in Canadian hospitals is shown in Table 6.6.4. Resistance like this increases health care costs as it may limit treatment to more expensive and longer courses of antibiotic therapy, require the isolation of infected patients, or lead to longer hospital stays.[6] These effects are of particular importance to children, the elderly and those suffering from HIV and other infections that can compromise the immune system.

Table 6.6.4
Penicillin Resistance in *Streptococcus pneumoniae* in Canada, 1988-1996

	Intermediate resistance	Resistant
	percent	
1988	2.4	-
1993	6.7	2.2
1994	7.4	2.2
1995	6.9	2.6
1996	8.8	4.5

Note:
These were clinically significant isolates submitted from approximately 50 clinical laboratories that service doctors' offices and hospitals across Canada.
Source:
Dr. D.E. Low, Canadian Bacterial Surveillance Network, Microbiology Department, Mt. Sinai Hospital, Toronto, personal communication.

Food-borne illness

What we eat, where it comes from, and how it is grown, processed, marketed and prepared have all changed dramatically in the last 50 years. These developments stem from increased trade, new technology, the changing tastes and demands of consumers, and the drive to improve the economic efficiency of agriculture.

Food-borne illness has changed in tandem with these developments in the food system and through adaptations of the disease-causing agents themselves.[7] Familiar pathogens like *Salmonella* maintain their presence, while new agents like *E. coli* O157:H7 and *Campylobacter* appear more frequently (Figure 6.6.4). Consumer behaviour also plays a role in food-borne illness. As illustrated in Figure 6.6.5, the rates of incidence for food-borne illness are highest in the summer months when people cooking and eating outside may be less likely to wash their

1. Health Canada, 1997, *Health and Environment: Partners for Life*, Catalogue No. H49-112/1997E, Ottawa.
2. Statistics Canada, 1998, *Canadian Social Trends*, Catalogue No. 11-008-XPE, No. 49, Ottawa.
3. Health Canada, 1995, *Exposure Guidelines for Residential Indoor Air Quality: A Report of the Federal–Provincial Advisory Committee on Environmental and Occupational Health*, Catalogue No. H46-2/90-156E, Ottawa.
4. *Ibid.*
5. In recent years, a new infectious agent, prion proteins, has been identified as the possible cause of new-variant Creutzfeld-Jakob disease (the equivalent of 'mad cow' disease in humans).
6. U.S. Congress Office of Technology Assessment, 1995, *Impacts of Antibiotic-resistant Bacteria*, U.S. Government Printing Office, Washington, D.C.
7. Fox, N., 1997, *Spoiled: The Dangerous Truth About a Food Chain Gone Haywire*, Basic Books, New York.

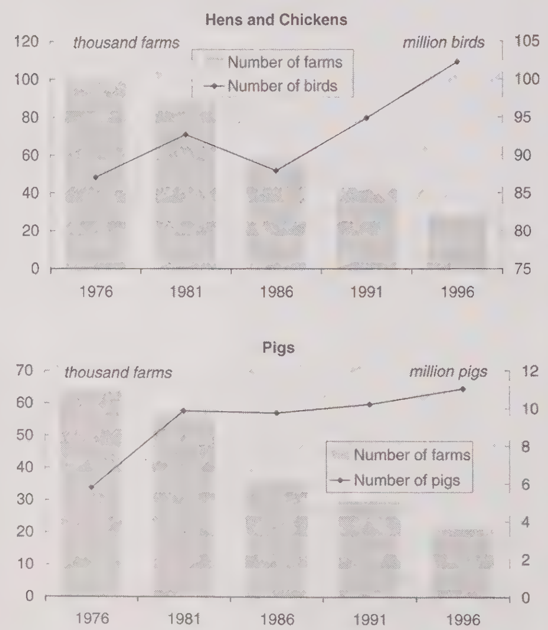
Text Box 6.6.1
Antibiotics and Livestock

Antibiotic resistance in the bacteria found in livestock is a health concern because several of these organisms also infect humans (e.g., *Salmonella, E. coli* and *Campylobacter*).

Changes in the structure of the Canadian livestock industry have led to a general decrease in the number of livestock farms while the number of animals on farms has increased. Individual farms thus support more animals than in the past. These larger animal populations pose a management challenge from the standpoints of both preventing and limiting the impact of livestock diseases.

Antibiotics are used to treat infections in farm animals, and are added to their feed to promote growth and prevent yield-lowering infections. Therapeutic uses are short-term and involve relatively high antibiotic doses, providing little opportunity for the development of resistance in bacterial populations. In contrast, the long-term use of antibiotics at the low doses found in feed does create a potential breeding ground for this trait.[1]

Changes in the Production of Confined Livestock, 1976-1996

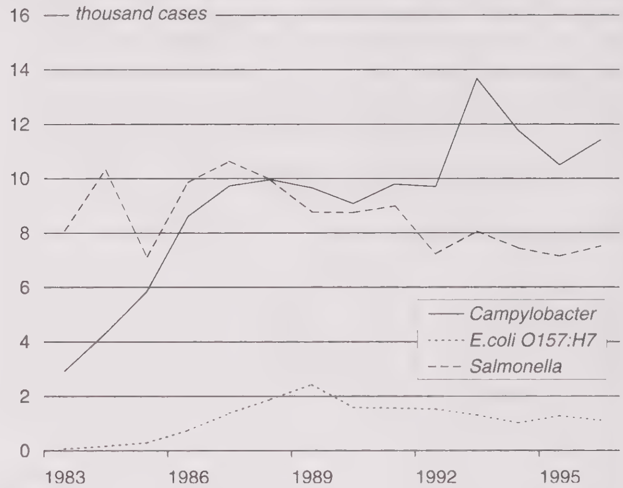


Source:
Statistics Canada, 1997, *Historical Overview of Canadian Agriculture*, Catalogue No. 93-358-XPB, Ottawa.

1. Khachatourians, G.G., 1998, "Agricultural Use of Antibiotics and the Evolution and Transfer of Antibiotic-resistant Bacteria," *Canadian Medical Association Journal*, Vol. 159, No. 9, pp. 1129-1136.

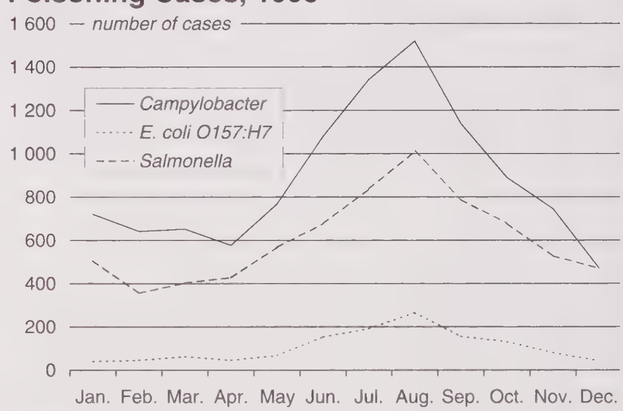
hands properly, cook food to proper temperatures or store food at the correct temperature.

Figure 6.6.4
Prevalence of Enteric Pathogens, 1983-1996



Note:
Data for 1996 are provisional.
Source:
Health Canada, Bureau of Microbiology, Laboratory Centre for Disease Control.

Figure 6.6.5
Seasonal Distribution of Confirmed Food Poisoning Cases, 1995

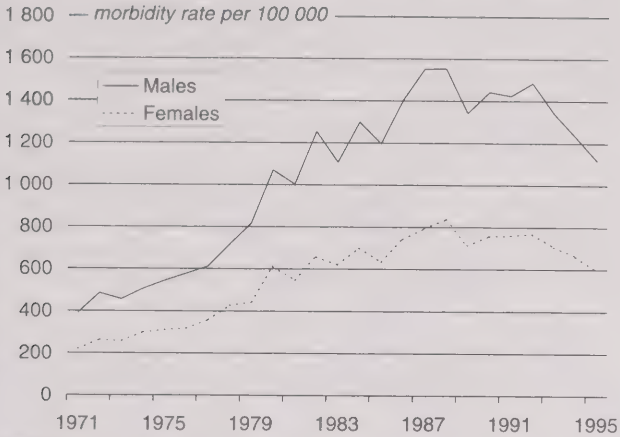


Source:
Health Canada, Bureau of Microbiology, Laboratory Centre for Disease Control.

Other health issues

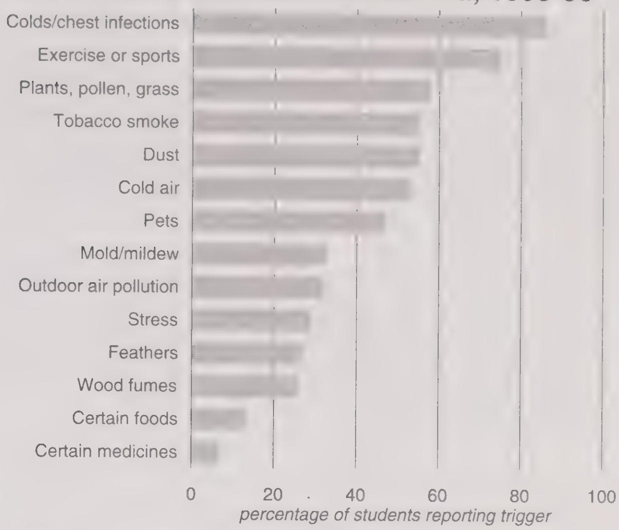
Several other issues are worthy of mention when considering environmental impacts on human health. A few of these are briefly mentioned below.

Figure 6.6.6
Age-Standardized Morbidity Rates of Asthma for Children Aged 1 to 4 Years, 1971-1995



Source:
Health Canada, Bureau of Microbiology, Laboratory Centre for Disease Control.

Figure 6.6.7
Asthma Triggers Reported by 5- to 19-year-old Students with Current Asthma, 1995-96



Source:
Health Canada, Bureau of Microbiology, Laboratory Centre for Disease Control

Children's health

Because of their size, incomplete development, greater rate of respiration and habits (e.g., contact with dirt through play), children have a greater susceptibility to the toxic effects of some pollutants.

Asthma, a disease often associated with childhood, has become more common in the last few decades (Figure 6.6.6). There is at present no proof that asthma is *caused* by exposure to environmental pollutants at the levels most Canadians experience, although there is no doubt that some of these substances trigger asthmatic responses (Figure 6.6.7).

Asthma provides a particularly good illustration of the difficulties involved when linking human health conditions to the environment. As with most illnesses, the disease appears to be caused by a combination of genetic, environmental and lifestyle factors accompanied by changing awareness of the condition. We do know, however, that common pollutants exacerbate the illness, and there is thus a definite link between the environment and the prevalence of symptoms associated with this disease.

Noise

Occupational exposure to noise is a well-studied health risk, but exposure to noise outside the workplace is not as well understood. People are aware that hearing loss is a health impact resulting from exposure to excessive noise, in terms of both volume and duration. Health impacts can also result from what most people would consider to be normal levels of noise. These impacts are indirect, and can be the result of sleep loss, stress and distraction from work or leisure activities. Sources of environmental noise pollution include air and road traffic, construction, recreational vehicles and the general day-to-day noises associated with household activities and appliances. More research is needed to understand the potential health impacts of this common pollutant.

Our health has improved in recent decades despite the emergence of several negative factors linked to human activity and behaviour. Medical advances, changing habits and better awareness of nutrition have all contributed to increasing the life expectancy of Canadians from approximately 60 years in the 1920s to over 75 years today.[1]

1. Life expectancy at birth in 1996 was 81.4 years for women, and 75.7 years for men (Statistics Canada, 1998, *The Daily,* April 16, Catalogue No. 11-001E, Ottawa).

Ecosystems under pressure

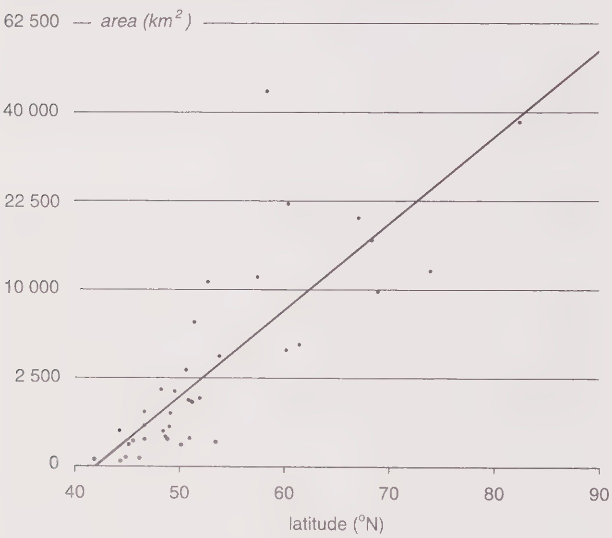
More and more of Canada's land cover is being altered from its natural state. As a result of agriculture, urban development, and forestry, mining and other resource extraction processes, Canada is losing natural areas that are critical for the survival of many plant and animal species. In some instances, such as the introduction of exotic species into ecosystems, human activity has played a subtler role in transforming nature.

One approach to the loss of natural areas and the potential extinction of species is the creation of a network of protected areas. In Canada, many instruments are used to manage and protect the natural environment. Each one of these entails specific objectives, constraints and management methods.

6.7 Protected areas

In the late 1800s, the first protected areas were created in Canada to preserve exceptional scenic settings for recreation and tourism activities and to protect wildlife. This led to the creation of Canada's first national park at Banff, Alberta, in 1885. More recently, the objective of protected areas has expanded to include providing educational and research opportunities and maintaining biodiversity.

Figure 6.7.1
National Park Area and Latitude



Source:
Adapted from Canadian Heritage, 1998, *State of the Parks, 1997 Report*, p. 36, Ottawa..

Table 6.7.1
Management Authority of Government-owned Protected Areas, 1997

Management authority	Number of sites	Total area of sites	Average area protected by each site
		km^2	
Federal	301	375 787	1 248
Provincial/territorial	2 326	481 606	207
Other	681	1 334	2

Note:
In the Canadian Conservation Areas Database, the management authority of government-owned protected areas is not available for 27 sites (143 km^2).
Sources:
Canadian Council on Ecological Areas, Canadian Conservation Areas Database.
Statistics Canada, Environment Accounts and Statistics Division.

6.7.1 Management of protected areas

Protected areas are defined as legally established areas (both land and water) that are regulated and managed for conservation objectives. Parks Canada and the Canadian Wildlife Service play important roles in the protection of natural areas at the federal level. The former is responsible for the national parks system, while the latter manages migratory bird sanctuaries, and national and marine wildlife areas.

National parks cover 2.3% of Canada's territory. The size and distribution of these parks have been determined by the history and geography of human land use. The southern regions of Canada are warmer and moister and characterized by more intensive and extensive land use—agriculture, forestry, urbanization—than those in the north. As a result, national parks in the regions further north tend to be larger (Figure 6.7.1).[1]

The provincial and territorial governments manage the largest portion of protected area in Canada, in terms of both number of sites and overall size (Table 6.7.1). However, the federal government manages the largest single parcels of protected area.

Area protected in Canada

In Canada, about 1 in every 12 km^2—more than 8% of the total land area—has been set aside as protected area. This share varies from province to province; in 1997, for example, it ranged from 1.8% in Prince Edward Island to 12.5% in the Yukon Territory (Table 6.7.2 and Text Box 6.7.1). Canada follows the international norm recommending that 12% of its surface be protected.[2]

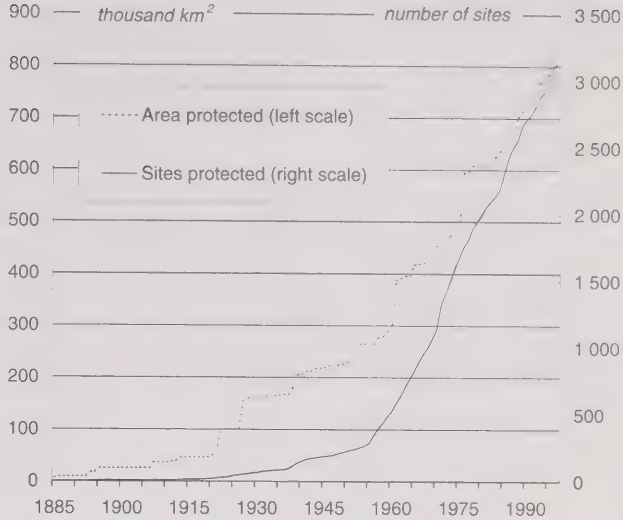
1. Canadian Heritage, 1998, *State of the Parks, 1997 Report*, Ottawa.
2. Government of Canada, 1990, *Canada's Green Plan: Canada's Green Plan for a healthy environment*, Hull.

Table 6.7.2
Total Area Protected by Province and Territory, 1997

Province/Territory	Total area protected	Total land[1]	Total area protected as a share of total land
	km²		percent
Newfoundland	7 521	405 720	1.9
Prince Edward Island	101	5 660	1.8
Nova Scotia	2 902	55 490	5.2
New Brunswick	4 179	73 440	5.7
Quebec	159 360	1 540 680	10.3
Ontario	67 162	1 068 580	6.3
Manitoba	72 875	649 950	11.2
Saskatchewan	23 082	652 330	3.5
Alberta	74 714	661 190	11.3
British Columbia	94 998	947 800	10.0
Yukon Territory	60 326	483 450	12.5
Northwest Territories	291 651	3 426 320	8.5
Canada	**858 870**	**9 970 610**	**8.6**

Note:
1. Includes freshwater bodies.
Sources:
Canadian Council on Ecological Areas, Canadian Conservation Areas Database.
Statistics Canada, Environment Accounts and Statistics Division.

Figure 6.7.2
Area and Number of Sites Protected, 1855-1997



Note:
In the Canadian Conservation Areas Database, the year of establishment for 203 protected sites (24 161.2 km²) is not available.
Sources:
Canadian Council on Ecological Areas, Canadian Conservation Areas Database.
Statistics Canada, Environment Accounts and Statistics Division.

Establishment of protected areas

A number of factors impede the establishment of protected areas, notably the availability of public land (legal protection is typically granted to publicly owned areas), the current use of the land in question, and the population density. The use of land for agriculture, human settlements, intensive recreational activities and other human activities reduces opportunities for land protection.

In the late 1950s, there was a significant increase in the rate of creation of protected areas (Figure 6.7.2). This coincided with increased recognition of the importance of the environment and, specifically, the need to protect natural areas.

Fewer protected areas were created before the 1950s but they were larger in size. The average size of a protected area created on or before 1955 is more than 930 km²; for those created after 1955, it is about 200 km².

Types of protection in Canada

The type of protection accorded to a natural area depends on its management and conservation objectives. Some protected areas allow logging, hunting and mining, while others exclude virtually all human activities. The World Conservation Union (IUCN)[1] has developed a classification scheme (Table 6.7.3) that is used throughout the world (Table 6.7.4).

1. The World Conservation Union still uses the IUCN acronym from its former name—International Union for the Conservation of Nature.

Text Box 6.7.1
Ontario's Living Legacy: A Complete System of Protected Areas

Ontario's Living Legacy is a land use strategy that includes the largest increase ever in Ontario's system of parks and other protected areas. This strategy applies to millions of hectares of forested lands, lakes, rivers and streams across a planning area from a line just north of Peterborough to the 51st parallel.

The Living Legacy strategy builds on the work of the Lands for Life planning process, launched in February 1997. This process was designed to address the needs of resource-based industries and to enhance opportunities for recreational activities such as angling and hunting.

In March 1999, as a result of the Lands for Life planning process, the Ontario Ministry of Natural Resources announced that the Living Legacy strategy would add 378 new parks and other protected areas totalling 2.4 million hectares. This addition would almost double the amount of parkland and other protected areas in Ontario.

Source:
Ontario Ministry of Natural Resources, *Ontario's Living Legacy: Highlights*. <www.mnr.gov.on.ca/MNR/oll/>, (accessed July 30, 1999).

Table 6.7.3
IUCN Classification Framework[1]

IUCN category	Defining characteristics	Management goals or practices
I. Nature reserve or wilderness area		
a. Nature reserve	possesses some outstanding or representative ecosystems, geological or physiographic features, or species	scientific research or ecological monitoring
b. Wilderness area	large areas, unmodified or slightly modified, retaining their natural character and influence, without permanent or significant habitation	preservation of wild conditions
II. National park (or equivalent)	designated to sustain the integrity of one or more ecosystems, exclude exploitation or intensive occupation, and provide a foundation for scientific, educational, recreational and visitor opportunities, all of which must be ecologically and culturally compatible	ecosystem protection and recreation
III. Natural monument	contains one or more specific natural or cultural features of outstanding or unique value because of inherent rarity, representative aesthetic qualities or cultural significance	protection of specific outstanding natural features; provision of opportunities for research and education
IV. Habitat/species management areas	areas important to ensuring the maintenance of habitats for meeting the requirements of certain species	management (e.g., securement and maintenance) of habitat and species where human manipulation is required
V. Protected landscape or seascape	areas where interactions of people and nature have produced a distinct character with significant cultural or ecological value and often with high biodiversity	conservation, education, recreation and provision of natural products aimed at safeguarding the integrity of harmonious interactions of nature and culture
VI. Managed resource-protected areas	predominantly natural areas that are large enough to absorb sustainable resource uses without harming long-term maintenance of biodiversity	long-term protection and maintenance of biodiversity and other natural values and the promotion of sound management practices for sustainable production purposes

Note:
1. Based on the amended 1994 IUCN criteria.
Sources:
Environment Canada, 1996, *The State of Canada's Environment 1996*, Ottawa.
World Conservation Union (IUCN), 1994, *Guidelines for Protected Areas Management Categories*, Gland, Switzerland and Cambridge, U. K.

Table 6.7.4
Examples of Protected Areas by IUCN Category

IUCN category	Examples
I. Nature reserve or wilderness area	Bay du Nord, Nfld.
	Windigo Bay Provincial Nature Reserve, Ont.
	Thelon Wildlife Sanctuary, N.W.T.
II. National park (or equivalent)	Fundy National Park, N.B.
	Taylor's Head Provincial Park, N.S.
	Pacific Rim National Park, B.C.
III. Natural monument	Parrsboro Fossil Cliffs, N.S.
	Nipekamew Sand Cliffs, Sask.
	Île Bonaventure et Rocher Percé Provincial Park, Que.
IV. Habitat/species management areas	Algonquin Provincial Park, Ont.
	Sleeve Lake Wildlife Management Area, Man.
	Black Pond Migratory Bird Sanctuary, P.E.I.
V. Protected landscape or seascape	Cooking Lake Blackfoot Provincial Reserve, Alta.
	Tobin Lake Campground, Sask.
	Peel River Game Reserve, Y.T.
VI. Managed resource-protected areas	Big Mud Lake Management Area, Ont.
	Cap Tourmente National Wildlife Area, Que.
	Atton's Lake Regional Park, Sask.

Source:
Canadian Council on Ecological Areas, Canadian Conservation Areas Database.

In 8 of the 12 provinces and territories, 60% of the protected area is given Category I or Category II protection (Table 6.7.5). The relatively high proportion of land given these types of protection, particularly Category II, is due to the numerous provincial and national parks across the country. In Alberta and British Columbia, Category II protection is dominant: for every 100 km^2 protected, about 95 km^2 are protected under Category II. In New Brunswick, 80% of all the protected area falls under Category IV. In Quebec, about 95% of the protected area is conserved under Category IV or Category V.

6.7.2 Role of non-governmental organizations

Numerous non-governmental organizations (NGOs) in Canada are also involved in the protection of natural areas.[1] Ducks Unlimited Canada, the Wildlife Habitat Foundation Canada and the Nature Conservancy of Canada are key national players. Their presence has been growing in the past decades. Between 1987 and 1996, NGOs were responsible for creating over 70% of the protected sites in the Atlantic provinces (Figure 6.7.3). The size of the protected areas created by these organizations is usually small (around 0.5 km^2 on average) since they generally need to purchase the land for protection.

In the last 50 years, Canada has made important strides in protecting its natural areas. However, human activities like poaching, vandalism and recreational overuse and environmental stresses such as acid rain, climate change, water pollution and habitat alteration are on-going threats to these areas.

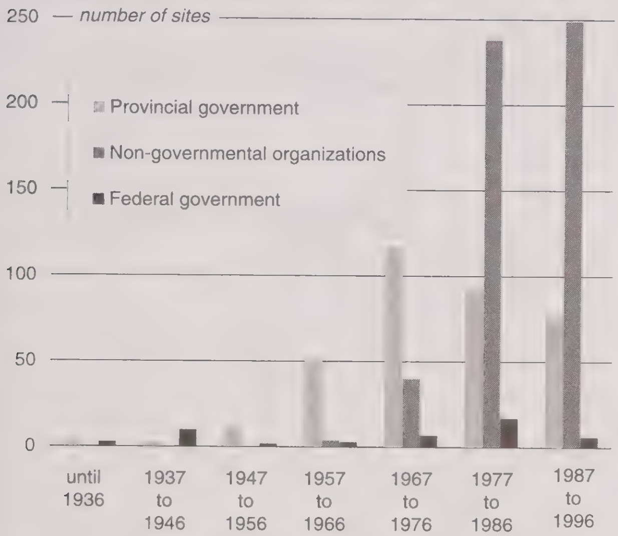
1. Areas protected by NGOs do not carry any legal status. Therefore, they have not been included in any calculations of Canada's total protected areas.

Table 6.7.5
Total Area Protected by IUCN Category, Province and Territory, 1997

Province/Territory	Total area protected	Total area protected by IUCN category						Proportion of total area protected by IUCN category					
		I	II	III	IV	V	VI	I	II	III	IV	V	VI
	km²							percent					
Newfoundland	7 521	4 074	2 534	32	263	618	-	54.2	33.7	0.4	3.5	8.2	-
Prince Edward Island	82	-	41	-	42	-	-	-	49.3	-	50.7	-	-
Nova Scotia	2 897	14	1 431	--	1 452	-	-	0.5	49.4	--	50.1	-	-
New Brunswick	4 084	51	670	-	3 364	-	-	1.3	16.4	-	82.4	-	-
Quebec	159 360	954	6 670	308	76 977	74 374	78	0.6	4.2	0.2	48.3	46.7	--
Ontario	67 162	42 440	15 664	1	8 140	859	58	63.2	23.3	--	12.1	1.3	0.1
Manitoba	70 037	26 334	16 623	32	13 847	7 125	6 076	37.6	23.7	--	19.8	10.2	8.7
Saskatchewan	23 082	2 443	11 585	54	1 161	581	7 259	10.6	50.2	0.2	5.0	2.5	31.4
Alberta	74 714	1 303	70 680	57	2 568	105	-	1.7	94.6	0.1	3.4	0.1	-
British Columbia	94 995	4 018	90 501	-	330	146	-	4.2	95.3	-	0.3	0.2	-
Yukon Territory	60 326	181	36 527	-	20 618	3 000	-	0.3	60.5	-	34.2	5.0	-
Northwest Territories	291 651	57 329	116 265	16	113 615	4 427	-	19.7	39.9	--	39.0	1.5	-
Canada	**855 912[1]**	**139 142**	**369 189**	**498**	**242 376**	**91 235**	**13 472**	**16.3**	**43.1**	**0.1**	**28.3**	**10.7**	**1.6**

Notes:
Federal protected areas are included in the provincial figures.
1. In the Canadian Conservation Areas Database, the category of IUCN protection is not available for 2 958.9 km², mostly located in Manitoba.
Sources:
Canadian Council on Ecological Areas, Canadian Conservation Areas Database.
Statistics Canada, Environment Accounts and Statistics Division.

Figure 6.7.3
Protected Areas Created by Decade and Jurisdiction, Atlantic Provinces



Source:
Environment Canada, Atlantic Region, Atlantic Region Conservation Areas Database.

6.8 Species at risk

The disappearance (extinction) of a species is a biological phenomenon that has existed since the beginning of life on earth. It results from the elimination of species that can no longer adapt to a constantly evolving environment. However, while extinction of species in the past was of natural origin (for example, as a result of volcanic activity or falling meteorites), the disappearance of modern species is increasingly the result of human activities.[1] The pace at which species are becoming extinct has also accelerated. Between 1600 and 1900, species disappeared at the rate of one every four years. Today they disappear at the rate of between one and three species per day.[2]

As of 1999, 27 animal and plant species[3] had disappeared in Canada. Twelve of these are no longer found anywhere on earth. Residual populations of the rest may still be found elsewhere in the world (Table 6.8.1). Numerous populations were overexploited and decimated before hunting laws were adopted. Other more recent extirpations resulted from farming, logging, industrial pollution and other human activities that have destroyed essential habitats.

1. Burnett, J.A. *et al.*, 1989, *On the Brink: Endangered Species in Canada*, Western Prairie Producer Books, Saskatoon.
2. Environment Canada, Canadian Wildlife Service, 1996, *Endangered Species in Canada*, Catalogue No. CW69-4/76-1996E, Ottawa.
3. Includes all geographically defined wild and indigenous plant or animal populations, varieties, subspecies and species.

6.8.1 Status of wildlife

Since 1978, the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) has studied more than 490 species, 339 of which are presently on the list of species at risk (Table 6.8.2). The latter, however, represent only a minute portion of the tens of thousands of known Canadian species. COSEWIC classifies species at risk according to five categories:

- *Extinct*: a species that no longer exists.
- *Extirpated*: a species that no longer exists in the wild in Canada, but appears elsewhere in the world in captivity or in the wild.
- *Endangered*: a species facing imminent extirpation or extinction.
- *Threatened*: a species likely to become endangered if limiting factors are not reversed.
- *Vulnerable*: a species of special concern because of characteristics that make it particularly sensitive to human activities or natural events.

A large number of species at risk are predators requiring vast territories, specialized species requiring specific habitats, and migratory species requiring specific habitats for each season.[4] The number of such groups has grown

4. Gayton, D., 1997, "Terms of endangerment: Saving species begins with saving spaces for them," *Canadian Geographic*, May–June, pp. 30–41.

Table 6.8.1
Species Extinct and Extirpated in Canada, 1999

Species	Group	Last sighting	Probable cause(s) of extinction or extirpation
Karner blue butterfly	lepidopteran	1991	habitat alteration
Benthic Hadley Lake stickleback	fish	late 1980s	introduced predators
Limnetic Hadley Lake stickleback	fish	late 1980s	introduced predators
Frosted elfin butterfly	lepidopteran	1988	successional change
Greater prairie chicken	bird	1987	habitat alteration
Banff longnose dace	fish	1986	introduced predators
Longjaw cisco	fish	1975	commercial fishing; introduced predators
Black-footed ferret	mammal (terrestrial)	1974	loss of food source
Dwarf wedgemussel	mollusc	1968	habitat alteration
Blue walleye	fish	1965	habitat alteration; commercial fishing
Sage grouse (British Columbia population)	bird	1960	hunting; habitat alteration
Gravel chub	fish	1958	habitat alteration
Blue-eyed Mary	plant	1954	habitat alteration
Deepwater cisco	fish	1952	commercial fishing; introduced predators
Eelgrass limpet	mollusc	1929	disease
Dawson's caribou (Queen Charlotte Islands population)	mammal (terrestrial)	1920	hunting
Paddlefish	fish	1917	habitat alteration
Passenger pigeon	bird	1914	hunting; habitat alteration
Island marble butterfly	lepidopteran	1908	loss of food source
Pygmy short-horned lizard (British Columbia population)	reptile	1898	habitat alteration
Sea mink	mammal (marine)	1894	trapping
Illinois tick trefoil	plant	1888	habitat alteration
Grizzly bear (Prairie population)	mammal (terrestrial)	1880	habitat alteration; human intolerance
Labrador duck	bird	1875	hunting; habitat alteration
Atlantic walrus (northwest Atlantic population)	mammal (marine)	1850	excessive commercial hunting
Great auk	bird	1844	hunting
Gray whale (Atlantic population)	mammal (marine)	1800	excessive hunting

Sources:
Environment Canada, Canadian Wildlife Service, COSEWIC, 1999, *Canadian Species at Risk*, Ottawa.
Environment Canada, 1996, *The State of Canada's Environment 1996*, Ottawa.

Table 6.8.2
Species Extinct and at Risk in Canada, 1999

Group	Status assessment					
	Extinct	Extirpated	Endangered	Threatened	Vulnerable	Total
	number					
Mammals						
Terrestrial	1	2	6	5	19	33
Marine	1	2	6	5	8	22
Birds	3	2	18	7	22	52
Fish	6	2	4	18	42	72
Amphibians	-	-	2	1	9	12
Reptiles	-	1	4	6	8	19
Molluscs	1	1	4	2	-	8
Lepidopteran	-	3	1	-	1	5
Vascular plants	-	2	40	30	39	111
Lichens	-	-	1	-	3	4
Mosses	-	-	-	1	-	1
Total	**12**	**15**	**86**	**75**	**151**	**339**

Source:
Environment Canada, Canadian Wildlife Service, COSEWIC, 1999, *Canadian Species at Risk*, Ottawa.

considerably over the past few years, from 178 species at risk in 1988 to 339 in 1999. This situation is not a true indicator of the rate at which species are becoming at risk, but rather of the speed with which COSEWIC can study wild species. Tables 6.8.3 to 6.8.6 present certain endangered species in Canada.

Human activities

Farming, which monopolizes vast tracts of land, is one of the human activities that has the greatest impact on wildlife. Deforestation, the replacement of indigenous plants with other crops, the drying of wetlands and the use of insecticides and herbicides have reduced the populations and areas of distribution of numerous species and also resulted in the introduction of new species. Major wildlife habitats in Canada have disappeared and continue to disappear. More

Table 6.8.3
Endangered Species of Birds in Canada

Species	Critical habitat	Comments	Probable stress or limiting factors
Eskimo curlew	tundra and wooded transition zones	almost disappeared between 1880 and 1895; shorebird	human disturbance and hunting; loss of habitat
Harlequin duck (Eastern population)	breeds in turbulent mountain streams and fast rivers	very small numbers; population apparently still declining; fewer than 1 500 individuals	habitat degradation from hydro-electric development and other natural resource extraction industries; marine pollution
Henslow's sparrow	meadows and large grassy fields abandoned by agriculture; breeds in southern Ontario	long-term population decline; current population may number fewer than 10 pairs	loss of habitat from land development and intensive cultivation
Kirtland's warbler	stands of small, young grey pines growing in well-drained sandy soil	long-term decline of population seems to have stabilized; rare throughout North America	disappearance of breeding habitat
Loggerhead shrike (Eastern population)	flat or very gently rolling open land; extensive fields of rough pasture	small numbers (about 80 birds); widespread decline of populations in eastern Canada	loss of breeding and wintering habitat; pesticide contamination; road traffic; climatic changes; predation
Mountain plover	flat, heavily grazed natural grassland; extreme southeastern Alberta and extreme southwestern Saskatchewan	low numbers; at northern limit of its range	destruction of habitat: replacement of native grassland by cereal crops; lack of suitable habitat for nesting; hunting
Roseate tern	islands or islets along coasts of Nova Scotia and Quebec	between 101 and 125 pairs in Canada	exploitation of wintering sites; predatory activities; competition with other bird species; contamination by toxic chemical products
Sage grouse (Prairie population)	hot, dry regions; reproduction: flatlands, small hummocks and ridges along valleys	largest Canadian grouse; only 10% to 15% succeed in reproducing	destruction of habitat: farming, and natural gas and petroleum development; predatory activities of coyotes
Piping plover	ocean beaches (east); river sandbanks and gravel shores of shallow freshwater and alkaline lakes (west)	uncommon; periodic population declines; breeding exclusively in aquatic regions; beach-dwelling shorebird	vacationers and illegal off-road vehicles on beaches (east); water development projects disturb lake levels (west); predation
Sage thrasher	breeds in sagebrush habitat; southern interior of British Columbia, southeastern Alberta and southwestern Saskatchewan	since 1980, only 5 to 10 pairs present; continuing threats to habitat	loss of habitat: mowing, burning and herbicide treatments; residential and agricultural development
Whooping crane	marshy areas (primarily those of Wood Buffalo National Park)	management programs to accelerate population recovery rate	hunting: accidental shooting; loss of habitat: expansion of agriculture; competition for food and space
Burrowing owl	heavily grazed pastures	long-term population decline; at northern limit of its distribution	loss of habitat: land development; pollution and contaminants; predation
Spotted owl	old growth forest in mountainous regions	very low numbers; at northern limit of its range	loss of habitat from timber harvesting
Prothonotary warbler	nests exclusively in deciduous swamps	nests in tree cavities; latest estimate: between 6 and 15 pairs	habitat degradation; contaminants; hunting
King rail	marshland habitats; southern Ontario	fewer than 20 breeding pairs	habitat loss and degradation

Note:
This table includes only certain species of endangered birds in Canada.
Source:
Environment Canada, COSEWIC, Canadian Wildlife Service, Ottawa.

Table 6.8.4
Endangered Species of Terrestrial and Marine Mammals in Canada

Species	Critical habitat	Comments	Probable stress or limiting factors
Swift fox	native prairie in Alberta and Saskatchewan	redesignated from extirpated to endangered in 1998; establishment of a breeding population in parts of its former range	overharvested as a fur bearer; secondary poisoning from wolf control; loss of habitat
White whale (beluga) (St. Lawrence River population)	large freshwater river estuaries of the St. Lawrence River	long-term declining population (about 550 animals); most southern population in world	overharvesting; hydro-electric dam construction; dredging; commercial fishing; movement of ships; pollutants and contaminants; food competitors
(Ungava Bay population)	leads and polynyas in winter; shallow bays and estuaries in summer	stocks reduced to point of immediate danger of extinction; no sign of population recovery	hunting; habitat alteration from damming of large rivers
(southeast Baffin Island/ Cumberland Sound population)	leads and polynyas in winter; shallow bays and estuaries in summer	stable population of about 400 whales for last 10 years	overharvesting
Right whale	Atlantic and Pacific coastal waters of North America, from tropics to subarctic	long-term population decline; about 120 whales in northwestern Pacific and 150 to 200 whales in northwestern Atlantic	commercially over-harvested; human disturbance
Vancouver Island marmot	rare and fragmented habitat: alpine and subalpine areas; steep slopes; talus debris; open meadows	long-term population decline; population estimated at about 150 animals	habitat alteration: forest harvesting and climatic changes; predation
Wolverine (Eastern populaiton)	northern Quebec and Labrador; occurs in large, sparsely inhabited wilderness areas with year-round food supplies	has declined to a very low level; only a few sightings in recent years	cannot be clearly determined; possibilities: overharvesting, loss of food source (caribou), habitat destruction and trapping
Marten (Newfoundland population)	mature coniferous and mixed forest; restricted to small portion of western Newfoundland (600 km^2)	despite complete protection from trapping since 1934, distribution and number have declined (small population of 300)	habitat destruction: logging and fires; excessive trapping; disease
Bowhead whale (Eastern Arctic population)	Baffin Bay; Hudson Bay; Davis Strait; estuaries	move north to south with retreat or advance of ice; no more than 600 whales	overharvesting; climatic factors that influence ice conditions
(Western Arctic population)	Bering Sea; Beaufort Sea	population might experience slight growth	overharvesting; offshore developments; movement and noise of ships
Peary caribou (Banks Island population)	river valleys and plains in summer; elevated and open areas in winter	sharp drop in population since beginning of 1970s	harsh winters; hunting; arctic ecosystem contamination; human disturbance
(High Arctic population)	river valleys and plains in summer; elevated and open areas in winter	precipitous decline from 25 000 animals in 1961 to fewer than 3 000 today; vulnerable to freezing rain	heavier snowfall and freezing rain in recent decades; starvation; hunting; wolf predation; human disturbance

Sources:
Environment Canada, COSEWIC, Canadian Wildlife Service, Ottawa.
Burnett, J.A. *et al.*, 1989, *On the Brink: Endangered Species in Canada*, Western Prairie Producer Books, Saskatoon.

Table 6.8.5
Endangered Species of Vascular Plants in Canada

Species	Distribution	Comments	Probable stress or limiting factors
Cucumber tree	limited distribution in southernmost Ontario	rapid decline in population has occurred; only a few seed-bearing trees in three sites; at northern limit of its range	human disturbance: lumbering, forest cleaning, and agriculture
Furbish's lousewort	narrow shaded bands of steep, eroded fluvial terraces	herb; a few hundred plants remain in Canada; found on banks of upper Saint John River, N.B.	hydro-electric projects and flooding
Heart-leaved plantain	moist depression in undisturbed, shaded, deciduous woodland; one site remains on eastern shore of Lake Huron	reduced population throughout its North American range	human disturbance: collection by Aboriginal people for medical purposes; loss of habitat: development
Pink coreopsis	found in Tusket River Valley, N.S. (six locations); restricted to gravelly margins of lakes	herb; intolerant of competition	human disturbance: residential development, reservoir construction and off-road vehicles
Pink milkwort	dry and sandy prairies; meadows; two sites only, at mouth of St.Clair River	herb; about 100 plants left	loss of habitat: expansion of agriculture; collecting; plant succession
Eastern prickly pear cactus (Eastern population)	dry, open locations like exposed prairies, dunes and rocky ridges, or dry and partially clear wooded areas	rarest cactus in Canada; restricted to four confirmed locations in southernmost Ontario	loss of habitat: changes in vegetation cover and agricultural expansion; human disturbance: collecting
Small white lady's-slipper	tall grass prairie; swampy meadows; fens; remnant prairies; edge of thickets	orchid; long-term decline throughout its range	loss of habitat: agricultural and urban development
Small whorled pogonia	one site in Elgin County, Ont.	rarest orchid in northeastern U.S. and Canada	human disturbance: rarity attracts attention; loss of habitat

Table 6.8.5
Endangered Species of Vascular Plants in Canada (continued)

Species	Distribution	Comments	Probable stress or limiting factors
Southern maidenhair fern	Fairmont Hot Springs, B.C.	number of plants and sites decreasing	loss of habitat: reduced hot water flow, and competition from herbaceous species
American ginseng	rich and moist hardwood forest areas typically dominated by sugar maple	wild ginseng harvested and exported from eastern Ontario	destruction of habitat: urban and agricultural development, deforestation; overexploitation
Pitcher's thistle	sandy areas	species grows only in Great Lakes region	habitat modification: recreational uses
Western prairie white fringed orchid	ditches and mesic and wet tall-grass prairie near Vita, Man.	single location is mainly in private ownership; subject to habitat alteration	massive habitat loss from conversion to agriculture, mineral extraction, and grazing; successional change; loss of pollinators
Wood poppy	rich woods; forested ravines and slopes; woodland streams; ravine bottoms; Middlesex County, Ont.	only several hundred plants remain; two populations lost in recent years	logging; predation
Bluehearts	found in Lambton County, Ont. on narrow stretch of Lake Huron's shoreline	herb	loss of habitat: cottage development
Spotted wintergreen	oak and pine woodlands on humid or dry soils	only three small colonies in Ontario	habitat alteration and destruction
Large whorled pogonia	warm Carolinian zone in southernmost Ontario	three colonies	habitat destruction
Hoary mountain mint	along warm southerly slopes; Burlington Bay and western end of Lake Ontario	only one colony (about 40 plants); characteristic scent	habitat destruction; introduction of shrub species
Gattinger's agalanis	prairie ecosystem; southern Ontario	found in 10 locations	habitat alteration; urban and agricultural development
Skinner's agalanis	prairie ecosystem; southern Ontario	12 known colonies; generally just off roads and near buildings	habitat alteration; urban and agricultural development
Slender bush clover	open and dry habitats	survival linked to burning of lands on which species grows	habitat destruction; human disturbance
Eastern mountain avens	sphagnum bogs; humid and shallow depressions	about 12 small populations	habitat destruction: drainage; rival vascular plants; cottage development
Slender mouse-ear-cress	prairie region; in sandy alkaline soil; dry areas; eroded hillsides	little known about biology of species	loss of habitat; grazing; fire control; invasions of non-native species
Thread-leaved sundew	damp sands; sandy shores; cedar swamps; in Canada, mainly in dwarf shrub bogs	found in three sites, all within a 10-kilometre radius in southwestern Nova Scotia	drainage of bogs

Note:
This table includes only certain species of endangered vascular plants in Canada.
Sources:
Environment Canada, COSEWIC, Canadian Wildlife Service, Ottawa.
Burnett, J.A. *et al.*, 1989, *On the Brink: Endangered Species in Canada*, Western Prairie Producer Books, Saskatoon.

Table 6.8.6
Endangered Species of Amphibians, Reptiles and Fish in Canada

Species	Critical habitat	Comments	Probable stress or limiting factors
Northern cricket frog (amphibian)	along muddy and sandy shores; in emergent aquatic vegetation of ponds, marshes and ditches	occurs only on Pelee Island; long-term population decline; last sighting in 1987	substantial habitat loss; predation; fluctuating water levels in Lake Erie; pesticides and fertilizers
Northern leopard frog (amphibian) (Southern Mountain population)	temporary ponds, 30 to 60 metres in diameter, 1.5 to 2 metres deep and without any fish	species present only in British Columbia's Creston Valley Wildlife Management Area	introduction of non-indigenous fish; alteration of certain watercourses
Blue racer snake (reptile)	oak savannas; pastures; prairies	commonly known only to Pelee Island; about 200 adult snakes	loss of habitat: agriculture, and succession; killing by people; increase in development and tourism
Lake Erie water snake (reptile)	rocky shorelines; found solely in islands in western Lake Erie	clear decline in numbers of water snakes during the past 40 years	habitat destruction; killing by people
Leatherback turtle (reptile)	marine beaches serve as nesting areas	at northern limit of its distribution; biggest turtle on earth	fishing nets; pollution from non-biodegradable plastic; collection of eggs; loss of beaches for nesting; predation
Atlantic whitefish (fish)	Tusket and Petite rivers in southern Nova Scotia	small population; species distributed in Canadian waters only	pollution and contaminants; acidification of habitat; hydro-electric dams
Aurora trout (fish)	remote kettle lakes; limited to a small series of lakes in northeastern Ontario	disappeared from wild in early 1970s; management plan to rehabilitate species	lake acidification
Salish sucker (fish)	small lowland streams in lower Fraser Valley, B.C.	numbers of all populations have declined during last four decades; very limited distribution area; common until mid-1950s	increasing urbanization; habitat alteration

Note:
This table includes only certain species of endangered amphibians, reptiles and fish in Canada.
Source:
Environment Canada, COSEWIC, Canadian Wildlife Service, Ottawa.

Table 6.8.7
Number of Species at Risk and Mammal Species Extirpated in National Parks and National Park Reserves, 1997

National park/ National park reserve[1]	Species at risk	Mammal species extirpated[2]
Terra-Nova, Nfld.	6	3
Gros Morne, Nfld.	13	1
Prince Edward Island, P.E.I.	6	9
Kejimkujik, N.S.	10	5
Cape Breton Highlands, N.S	4	4
Fundy, N.B.	6	3
Kouchibouguac, N.B.	7	5
Forillon, Que.	9	3
Mingan Archipelago, Que.[1]	8	2
Mauricie, Que.	5	3
St. Lawrence Islands, Ont.	25	5
Point Pelee, Ont.	55	23
Georgian Bay Islands, Ont.	23	2
Pukaskwa, Ont.	11	-
Bruce Peninsula, Ont.	24	-
Riding Mountain, Man.	8	3
Wapusk, Man.	..	..
Prince Albert, Sask.	6	1
Grasslands, Sask.	13	-
Banff, Alta.	15	1
Waterton Lakes, Alta.	23	-
Jasper, Alta.	14	2
Elk Island, Alta.	7	3
Wood Buffalo, Alta. and N.W.T.	9	-
Glacier, B.C.	5	-
Yoho, B.C.	7	-
Mount Revelstoke, B.C.	6	-
Kootenay, B.C.	7	-
Pacific Rim, B.C.[1]	11	-
Gwaii Haanas, B.C.[1]	16	-
Kluane, Y.T.[1]	21	-
Ivvavik, Y.T.	14	1
Vuntut, Y.T.	..	..
Nahanni, N.W.T.[1]	9	1
Auyuittuq, N.W.T.[1]	7	-
Ellesmere Island, N.W.T.[1]	7	-
Aulavik, N.W.T.	..	..
Tuktut Nogait, N.W.T.	..	..

Notes:
1. A national park reserve is an area set aside as a national park pending settlement of any outstanding Aboriginal land claim.
2. Data are for native mammals only. These species have disappeared from some parks but continue to live elsewhere in Canada.

Source:
Canadian Heritage, 1998, *State of the Parks 1997 Report*, Catalogue No. R64-184/1997E, Ottawa.

than 30% of species at risk in Canada have lost millions of hectares of wetlands, swamps and other wet environments on which they depend for their survival.[1]

Other human activities—including urbanization, industrial and household pollution, and the harvesting of commercially valuable biotic resources such as trees and fish—also threaten numerous populations. For example, more than 80 species at risk in Canada depend on forests for their survival.[2]

Canadian national parks harbour more than 90 animal and plant species at risk and serve as a sort of refuge for them. However, these protected areas are also subject to stress from various sources and bear the marks of earlier land management practices. Therefore, a limited yet significant number of indigenous animal species have become extirpated in certain parks, although they may be found elsewhere in Canada (Table 6.8.7).

6.8.2 Conservation of species at risk

In 1988, government authorities created the Recovery of Nationally Endangered Wildlife Committee (RENEW). This committee was designed to save endangered, threatened and vulnerable species by developing plans to reintroduce each designated species. Text Box 6.8.1 describes progress achieved by certain species, and Table 6.8.8 lists RENEW funding by donor.

The Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) regulates the international trade of more than 30 000 species of wild plants and animals. A large number of wild Canadian species are in high demand in other countries. This includes the bear (for its gall bladder) and ginseng, both prized in other nations for their medicinal value. As a result, foreign demand creates a high market value for the harvesting of such species and could affect populations through overexploitation. Table 6.8.9 presents the number of permits issued in Canada for the export of wild species covered by CITES. Illegal trade is not included in these figures.

Table 6.8.8
Total RENEW Funding by Donor, 1988-1998

Donor	Share of total
	percent
Governments	69.6
Non-governmental organizations	18.6
Industry	8.3
Universities	3.0
Private contributions	0.5
Total	**100.0**

Source :
Environment Canada, Canadian Wildlife Service, 1998, *RENEW-Report No. 8, 1988-1998*, Ottawa.

1. Environment Canada, Canadian Wildlife Service, 1996, *Endangered Species in Canada*, Catalogue No. CW69-4/76-1996E, Ottawa.

2. Environment Canada, 1997, *Sustaining Canada's Forests: Forest Diversity*, National Environmental Indicator Series, EDE Bulletin No. 97-1, Ottawa.

Text Box 6.8.1

Status of Reintroduction of Certain Vertebrate Species

The wood bison was included on the list of species at risk in 1978, when only 450 animals remained in Canada. The species was on the brink of extinction in the late 1800s because of hunting and disease. Today, efforts at reintroduction have yielded six healthy herds in the wild, numbering 2 400 bison. Four herds raised in captivity total another 700 bison.

In 1941, only 21 whooping cranes remained in the wild throughout the world. Most of this species' breeding habitat has been destroyed and is now limited to 400 km^2 in four small areas of Wood Buffalo National Park in Alberta and the Northwest Territories. Through sustained efforts aimed at reintroducing the species, the whooping crane population totalled 190 in 1998.

In the years following the Second World War, the peregrine falcon (subspecies *Anatum*) rapidly declined to the brink of extinction. This bird of prey is vulnerable to chemical products like pesticides. In 1975, only 34 pairs remained in Canada. However, through the release of about 1 500 falcons over the years, the species has recolonized its former habitat. Recent population assessments indicate some 85 pairs of peregrine falcons are nesting in southern Canada, with more than 400 pairs in the Yukon Territory and Northwest Territories.

The swift fox is a small mammal that had been found throughout the Canadian Prairies in the 19th century. Over time, the fox suffered from loss of habitat and poisoning programs aimed at coyotes, wolves and squirrels. In 1978, the swift fox had been extirpated from Canada. Following a release program, nearly 300 foxes, constituting an autonomous and viable population, were well distributed across an adequate habitat in the Prairie provinces. In 1998, this species was downlisted from an extirpated species to an endangered species.

Over the years, other species also changed classes. The American white pelican, considered an endangered species in 1978, was removed from the list in 1987. The wood bison and the peregrine falcon (subspecies *Anatum*) were downlisted from endangered to threatened, while the peregrine falcon (subspecies *Tundrius*) and the ferruginous hawk were downlisted from endangered to vulnerable.

Efforts at reintroduction have not, however, succeeded in reversing the decline in species like the burrowing owl, the spotted owl or the Lake Erie water snake, nor have they succeeded in determining the key factors affecting these species.

Source:
Environment Canada, Canadian Wildlife Service.

Table 6.8.9

Number of Permits Delivered by Federal, Provincial and Territorial Governments for the Export of Wild Species Covered by CITES, 1989-1997

Jurisdiction	1989	1990	1991	1992	1993	1994	1995	1996	1997
Federal government	2 266	2 384	2 714	3 986	3 211	4 191	4 950	6 812	9 315
Newfoundland	1	1	1	69	57	80	92	119	129
Prince Edward Island	14	35	47	35	3	-	2	3	-
Nova Scotia	1	2	4	9	24	25	54	52	59
New Brunswick	-	3	44	536	957	1 274	1 196	1 154	1 165
Quebec	1 399	957	1 032	1 941	2 697	2 561	2 648	1 990	1 782
Ontario	671	511	683	4 455	5 618	5 883	6 451	4 526	5 446
Manitoba	137	157	165	799	1 260	1 806	1 690	1 722	2 116
Saskatchewan	70	42	48	286	1 095	1 089	1 123	1 288	492
Alberta	112	128	208	662	1 254	1 472	..	..	.
British Columbia	703	765	739	1 399	1 563	1 615	1 935	2 221	2 262
Yukon Territory	191	163	164	164	191	196	165	162	198
Northwest Territories	55	74	39	38	44	54	76	92	69
Total	**5 620**	**5 222**	**5 888**	**14 379**	**17 974**	**20 246**	**20 382**	**20 141**	**23 033**

Source:
Environment Canada, Canadian Wildlife Service, CITES, 1998, Ottawa.

6.9 Invasive species

Human activity has had a profound impact on the structure and function of many ecosystems. This impact is obvious in areas where agriculture, forestry, mining or urban development dominate the landscape. In some instances, however, the impact of human activity has been subtler. The introduction into ecosystems of exotic species is one such example.[1]

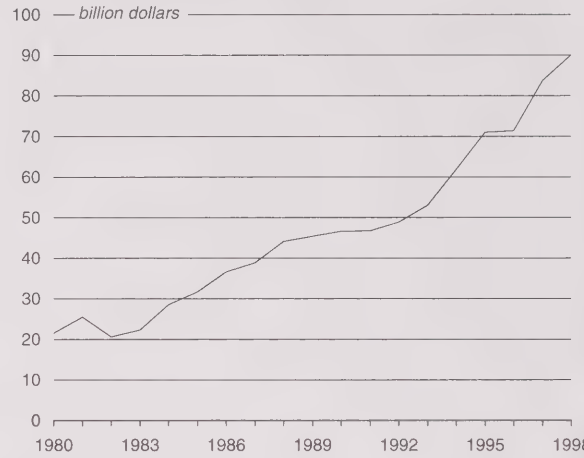
Exotic species are organisms that are not native to a given ecosystem. They include animals, microbes and plants that enter new areas when humans carry them across natural barriers, such as bodies of water, that normally limit their dispersal. Exotic species often integrate peacefully into their new surroundings. In fact, they may increase the biodiversity and complexity of their new habitat once established. Occasionally, however, an exotic species will displace native species or alter native habitats in a significant fashion as it establishes itself. These invasive species have been called biological pollutants. Unlike chemical pollutants, however, these biological invaders are able to reproduce themselves.

Pathways of invasion

During the early colonization of North America, it was not just European people that crossed the Atlantic: a host of plant and animal species came with them. Many of these species were brought along intentionally for agricultural, culinary, medicinal or ornamental purposes; however, several of them arrived as unintended stowaways. In addition to the standard shipboard fauna of rats and mice, species were introduced via contaminated animals, animal feed and bedding, ship ballast,[2] agricultural seed, foodstuffs, clothing and wood products.

Exotic species continue to be introduced into Canada via many of these same routes. In fact, there is greater potential to introduce foreign organisms today given the increased speed and quantity of international trade and transportation (Figure 6.9.1). Shipments of foodstuffs provide an obvious means of introduction, but the packing materials used in container ships (scrap wood called dunnage), ship ballast, and packaging materials (e.g., wooden cable spools and crating) may also harbour hidden organisms. Transportation equipment itself carries organisms, from gypsy moth egg masses on ships, to seeds stuck on cars and trucks, to zebra mussels in recreational boat motors. Animal and plant species may also follow human travel routes on their own. The opening of the Welland Canal, for example, allowed many aquatic organisms to enter the upper Great Lakes.[3] Clearly, human activity has provided many species with much more mobility.

Figure 6.9.1
Total Annual Imports to Canada from Outside North America, 1980-1998



Source:
Statistics Canada, CANSIM, matrix 3887.

Several behavioural and biological properties contribute to the potential success of an exotic species in a new habitat. These include prolific reproduction, rapid growth, early maturity, adaptability, aggressive behaviour and good dispersal mechanisms. Exotic species must also encounter favourable conditions to proliferate and become invasive. Absence of the predators, competitors and pathogens found in their native habitat is an important factor in creating these favourable conditions. So, too, is physical disturbance of an ecosystem: exposed soil, altered fire cycles, changed water levels, pollution, and species extinctions all make ecosystems more vulnerable to invasion.

Impacts

Invasive species affect ecosystems in many ways.[4] Primarily, they reduce native populations through predation, habitat destruction and competition for space, light and food. They may also have indirect social and economic consequences for humans. Consider Dutch elm disease, which ruined the appearance of city streets and led to financial losses as infested trees were removed.

1. The terms 'exotic' and 'introduced' are used interchangeably in this section to refer to non-native species. The term 'invasive' describes species of native or exotic origin that spread aggressively. This discussion focusses on invasive species of exotic origin.
2. Early ships used soil as ballast to fill empty cargo space for stability at sea. Modern ships use water, which is an equally efficient means of carrying species across the ocean. Faster transatlantic travel has increased the likelihood that organisms will survive the journey. Ballast contamination is one reason why the Great Lakes region has so many exotic species.
3. Other examples include purple loosestrife, which travels along roadside ditches, and the Colorado potato beetle, which developed a taste for potatoes and spread across North America once potato cultivation reached its native range.
4. The large body of literature on the environmental, economic and social impacts of invasive species gives us little quantification of these impacts. It is therefore difficult to assess accurately the magnitude of the invasive species problem.

Environmental impacts

Genetic invasion: Exotic species that are close relatives of native Canadian species cause problems by breeding with their Canadian cousins. This is the threat of the exotic white mulberry, which is breeding with the native red mulberry and contributing to the decline of the Canadian species.[1] The same process is occurring with the native black duck, which is hybridizing with the introduced mallard in northeastern North America.[2]

Displacement: Invasive species occupy space that would otherwise be occupied by native species. Indeed, invasive species have been identified as the main threat to biodiversity after habitat loss.[3] Habitat loss and the establishment of invasive species happen together in some cases. Urban environments provide the best example of this. Here, pigeons, rats and cockroaches—all introduced species—demonstrate a unique affinity for the new habitats we create.

Predation: By preying on native species, invasive organisms have an impact on established food webs. This has a greater significance for humans when the prey species is also used by fisheries, agriculture or forestry.

Ecosystem effects: Some invasive species have an indirect impact on native species through habitat change. They may, for example, displace species important for food or shelter, alter nutrient cycles, serve as a host for a pest or disease, or supply resources that favour a particular species. The chestnut blight fungus provides an example of this effect (Text Box 6.9.1).

Economic impacts

Economic impacts are most severe in ecosystems we either harvest or depend on for some other function. Perhaps the most serious economic impacts of introduced species are from agricultural and forestry pests (e.g., Colorado potato beetle, gypsy moth, Dutch elm disease, chestnut blight and many agricultural weeds). Costs come from both the control of the pests and the losses they cause. The United States Congress estimates cumulative losses from these pests between 1906 and 1991 to be $97 billion to $134 billion (in 1991 U.S. dollars).[4]

1. White, D.J., E. Haber and C. Keddy, 1993, *Invasive Plants of Natural Habitats in Canada: An Integrated Review of Wetland and Upland Species and Legislation Governing their Control*, North American Wetlands Conservation Council, Canada, <http://www.ec.gc.ca/cws-scf/habitat/inv/index_e.html>, (accessed March 19, 1998), Canadian Wildlife Service, Environment Canada, Ottawa.
2. St. Lawrence Centre, 1996, *State of the Environment Report on the St. Lawrence River, Volume 1: The St. Lawrence Ecosystem*, Part 2, Catalogue No. En153-70/1-1996E, Environment Canada and Éditions MultiMondes, Montréal.
3. Baskin, Y., 1996, "Curbing Undesirable Invaders," *BioScience*, Vol. 46, No. 10, pp. 732–736.
4. U.S. Congress, Office of Technology Assessment, 1993, *Harmful Non-Indigenous Species in the United States*, Catalogue No. OTA-F-565, U.S. Government Printing Office, Washington, D.C.

Text Box 6.9.1

Chestnut Blight and the Gypsy Moth

A few decades after its introduction, chestnut blight had virtually eliminated the American chestnut from eastern North American forests. These trees had formerly occupied up to 25% of the standing timber where they were present, and their loss represented a substantial change to the forest ecosystem. With the loss of both the timber and the food value of these trees came a more subtle impact. The chestnuts were succeeded by oaks, which proved to be the favourite food of the gypsy moth as it, in turn, spread across eastern North America.

Source:
Wallner, W.E., 1996, "Invasive Pests ('Biological Pollutants') and U.S. Forests: Whose Problem, Who Pays?," *EPPO Bulletin*, Vol. 26, pp. 167-180.

Other activities that can be negatively affected by invasive species include fishing (sea lamprey in the Great Lakes), recreation (Eurasian watermilfoil in waterways), and water supply and treatment (zebra mussels in water intakes). "It is estimated that [zebra] mussels will cause damage amounting to $4–5 billion in Canada and the United States over the next decade, due to fishery losses and costs associated with cleaning intakes and outfalls."[5] Exporters can suffer too if their products are placed under quarantine—witness the recent threat of the United States to ban nursery products from Vancouver Island because of the establishment of a population of gypsy moths on the island.[6]

The Canadian Food Inspection Agency and the Canadian Forest Service target ports of entry in an attempt to stop exotic species at the border. The United States and Canada, for example, both moved to ban the use of untreated wood packing materials in imports from China after inspections discovered the destructive Asian longhorned beetle in several locations in North America.

5. St. Lawrence Centre, *op. cit.*, p. 72.
6. Reported in *The Vancouver Province*, "Gypsy Moth Outbreak: Quarantine Zone May Be Imposed to Stop Pest Spreading," p. A4, October 16, 1998.

Table 6.9.1

Introduced Agricultural and Forestry Pests and Diseases in Canada[1]

Species	Place and date of discovery	Current area	Impacts/Notes
Dutch elm disease *Ophiostoma ulmi* and *O. novo-ulmi*	Quebec: 1944 (first discovery; introduction was probably before 1940)	present in all provinces except Newfoundland, Alberta and British Columbia	a fungus spread by the native elm bark beetle (*Hylurogopinus rufipes*) and the European elm bark beetle (*Scolytus multistriatus*); controlled through public education campaigns, surveillance, insecticides and sanitation (removal of diseased elms)
Gypsy moth[2] *Lymantria dispar*	Massachusetts: 1869; Kingston, Ont. region: 1969 (first record of defoliation in Canada); Vancouver: 1991 (Asian genotype adults detected)	established in southern Ontario, southern Quebec, southwestern New Brunswick and southwestern Nova Scotia	defoliation of forest trees; incurs costs through both quarantine and control measures; current control efforts involve the use of insecticide sprays; release of predatory and pathogenic species (dating back to the early 1900s) may have some influence on the current population declines in eastern Canada; native to Europe and North Africa
Pine shoot beetle *Tomicus piniperda*	Ohio: 1992; Niagara region: 1993	southern Ontario	new pest of concern; damages new shoots, weakening and defoliating trees; native to Europe and Asia
European larch canker *Lachnellula willkommii*	Massachusetts: 1920s; Maritimes: 1980	New Brunswick, Nova Scotia and Prince Edward Island	primary pathogen of larch trees; native to Europe
Potato blight *Phytophthora infestans*	eastern seaboard of North America: circa 1840	across Canada	leads to the complete destruction of susceptible potato crops; contributed to the Irish potato famine in the 1840s; origin uncertain
Colorado potato beetle *Lepinotarsa decemlineata*	extended its range during 1850s	across Canada	significant pest of potato crops; native to the western United States but fed on another species prior to the arrival of the potato in the 1850s; after discovering new host, quickly followed the potato path back across North America; good example of a species spread by habitat change
Asian long-horned beetle *Anaplophora glabripennis*	Brooklyn and Amityville, N.Y.: 1996; Chicago, Ill.: 1998; no known established populations in Canada	intercepted in warehouses in both Ontario and British Columbia	poses serious threat to Canadian hardwood forests (maple being the preferred host); expensive eradication effort (over $5 million to date in New York State alone) undertaken in Brooklyn, Amityville and Chicago after detection of established populations

Notes:

1. This table highlights only a few of the common pests and diseases.
2. This refers to the gypsy moth genotype established in North America. Egg masses of the Asian genotype have been detected on ships entering ports in British Columbia but it is not known to have established a population in the province. The Asian genotype is more invasive because, unlike the North American genotype, adult females are able to fly long distances.

Sources:

Animal and Plant Health Directorate, 1997, *Summary of Plant Quarantine Pest and Disease Situations in Canada, 1996*, Agriculture and Agri-Food Canada, Ottawa.

Humble, L. and A.J. Stewart, 1994, *Forest Pest Leaflet: Gypsy Moth*, Catalogue No. Fo29-6/75-1994E, Pacific Forestry Centre, Canadian Forest Service, Victoria.

Nealis, V.G. and S. Erb, 1993, *A Sourcebook for the Management of the Gypsy Moth*, Catalogue No. FO42-193/1993E, Great Lakes Forestry Centre, Forestry Canada, Sault Ste. Marie.

Table 6.9.2

Invasive Wetland Plant Species in Canada

Species	Place and date of discovery	Current area	Impacts/Notes
Eurasian watermilfoil *Myriophyllum spicatum*	Lake Erie: 1961	southern British Columbia, Ontario and Quebec	competes with native vegetation and interferes with fish species; affects recreational uses of water bodies; reproduces and spreads easily via stem fragments; particularly successful in sites cleared of other vegetation; seasonal breakdown can affect water quality, particularly through oxygen depletion and release of substantial quantities of phosphorus during decay; native to Europe
European frog-bit *Hydrocharis morsus-ranae*	Ottawa, Ont.: circa 1939 (escaped from Central Experimental Farm)	along the Great Lakes from Point Pelee to Quebec City, and north to Ottawa	dense floating mats block sunlight, affecting submerged species of plants and animals; inhibits recreational activities; mechanical removal is a temporary control measure; native to Europe and Asia
Flowering-rush *Butomus umbellatus*	La Prairie, Que.: 1897; numerous intentional introductions across Canada	coast to coast; more abundant in lower Great Lakes and along St. Lawrence River	competes with native vegetation; impedes small boat traffic; native to Europe and Asia
Glossy buckthorn *Rhamnus frangula* also known as *Frangula alnus*	London, Ont.: 1898; numerous intentional introductions	Nova Scotia to Manitoba; most abundant in southern Ontario	dense growths displace other species; host for crown rust fungus that afflicts oats; European starling, another introduced species, implicated as one agent contributing to the spread of buckthorn; native to Eurasia and North Africa
Purple loosestrife *Lythrum salicaria*	eastern Canada: established by 1880s (probably arrived in early 1800s); Alberni, B.C.: 1916; Charlottetown, P.E.I.: 1950; Lomond, Nfld.: 1973	coast to coast, primarily in the southern regions of the country; particularly prevalent in southern Ontario and Quebec	displaces native plant species and affects those animals that use the displaced native for food or shelter; still introduced as a garden ornamental; varieties once thought sterile have been shown to produce viable seeds through cross-pollination with wild varieties; controlled through mechanical, biological and chemical means; prolific seed producer; spread of purple loosestrife is aided by roadside ditches; damages irrigation ditches, drainage ditches and pasture land in addition to natural wetland sites; native to Europe and Asia
Reed canary grass *Phalaris arundinacea*	date uncertain	all provinces and territories (both native and introduced genotypes)	native and introduced varieties difficult to distinguish; European genotypes, introduced for hay and forage, have contributed to the spread; aggressive competitor that displaces other vegetation; often found in conjunction with purple loosestrife whose showiness tends to obscure presence of grass; native to temperate America and Eurasia

Sources:

Haber, E., *Invasive Exotic Plants of Canada: Fact Sheets 1 through 10*, Invasive Plants of Canada Project, <http://infoweb.magi.com/~ehaber/ipcan.html>, (accessed March 18, 1998).

White, D.J., E. Haber and C. Keddy, 1993, *Invasive Plants of Natural Habitats in Canada: An Integrated Review of Wetland and Upland Species and Legislation Governing their Control*, North American Wetlands Conservation Council, Canada, <http://www.ec.gc.ca/cws-scf/habitat/inv/index_e.html>, (accessed March 19, 1998), Canadian Wildlife Service, Environment Canada, Ottawa.

Table 6.9.3
Invasive Upland Plant Species in Canada

Species	Place and date of discovery	Current area	Impacts/Notes
Common buckthorn *Rhamnus cathartica*	frequent introductions: 1890s	Nova Scotia to Alberta	excludes native species; host for crown rust fungus that afflicts oats; native to Eurasia and North Africa
Garlic mustard *Alliaria petiolata*	Long Island, N.Y.: 1868; Toronto, Ont.: 1879	southern regions of Ontario and Quebec	threat (via shading) to endangered wood poppy and threatened white aster; mechanical and chemical methods used to control spread; native to Europe
Glossy buckthorn *Rhamnus frangula* also known as *Frangula alnus*	London, Ont.: 1898; numerous intentional introductions	Nova Scotia to Manitoba; most abundant in southern Ontario	dense growths displace other species; host for crown rust fungus that afflicts oats; European starling, another introduced species, implicated as one agent contributing to the spread of buckthorn; native to Eurasia and North Africa
Leafy spurge *Euphorbia esula*	New England coast: 1800s; Huron County, Ont.: 1889; believed to have been introduced in ship ballast (soil)	coast to coast; most prevalent in southern Manitoba and Saskatchewan	pest of agricultural fields and pastures; also competes with native grassland species; exhibits allelopathic properties; sticky sap an irritant to livestock; can foul farm equipment; native to Europe and Asia
Canada thistle *Cirsium arvense*	eastern Canada: 1600s	common across Canada	primarily invades agricultural ecosystems; according to Haber, "considered to be one of the most economically important agricultural weeds" in Canada; damages pastures; serves as a pest and pathogen host; increases cleaning costs of some crops; invades natural areas through disturbed sites; produces abundant seeds; spreads vegetatively; chemically inhibits the growth of other plants; native to southeastern Europe and eastern Mediterranean

Sources:
Haber, E., *Invasive Exotic Plants of Canada: Fact Sheets 1 through 10*, Invasive Plants of Canada Project, <http://infoweb.magi.com/~ehaber/ipcan.html>, (accessed March 18, 1998).
White, D.J., E. Haber and C. Keddy, 1993, *Invasive Plants of Natural Habitats in Canada: An Integrated Review of Wetland and Upland Species and Legislation Governing their Control*, North American Wetlands Conservation Council, Canada, <http://www.ec.gc.ca/cws-scf/habitat/inv/index_e.html>, (accessed March 19, 1998), Canadian Wildlife Service, Environment Canada, Ottawa.

Table 6.9.4
Invasive Aquatic and Terrestrial Animal Species in Canada

Species	Place and date of discovery	Current area	Impacts/Notes
Aquatic species			
Zebra mussel[1] *Dreissena polymorpha*	Ontario, Lake St. Clair: 1988 (thought to have arrived in ship ballast)	all Great Lakes, the St. Lawrence and Ottawa Rivers, and some inland lakes	each adult can filter about one litre of water per day, leading to decline in amount of plankton available to other species; displaces native mussels; spread by boats; clogs intake and outflow pipes of industrial, agricultural and municipal facilities; concentrates persistent pollutants in fatty tissues, serving as a vehicle for further biomagnification;[2] various mechanical and chemical means are used to reduce populations; eradication unlikely; native to the Caspian Sea
Sea lamprey *Petromyzon marinus*	Great Lakes via Welland Canal: circa 1921	all Great Lakes	fish predators; contributed to collapse of whitefish and lake trout populations; controlled through mechanical, chemical and biological means since 1956
Round goby *Neogobius melanostomus* Tubenose goby *Proterorhinus marmoratus*	Ontario, St. Clair River: 1990 (arrived in ballast water)	all Great Lakes, primarily Lake Erie	threat to Great Lakes fisheries via competition for habitat; voracious, aggressive and fecund fish species; round goby believed to contribute to contaminants entering food web by feeding on zebra mussels; native to Black Sea
Ruffe *Gymnocephalus cernuus*	Minnesota, Lake Superior: 1986; Thunder Bay, Kaministiquia River: 1991	western portions of lakes Superior and Huron	likely arrived in ballast water; threat to sport fisheries through competition for food and other resources; may consume trout and whitefish eggs; aggressive and fecund; practical control difficult; spread to other lakes a concern; native to Britain, northern Europe and Asia
Spiny water flea *Bythotrephes cederstroemi*	Lake Ontario: 1982; present in all Great Lakes by 1987	throughout Great Lakes and some inland lakes	likely arrived in ballast water; competes with small fish for plankton; too large to serve as food source for small fish; native to Great Britain and northern Europe
Rusty crayfish *Orconectes rusticus*	date uncertain; used as bait by anglers	several Ontario watersheds	competes with native crayfish species for stream vegetation; affects fish that use vegetation for food and/or cover; native to Kentucky-Ohio- Tennessee region
Terrestrial species			
Common starling *Sturnus vulgaris*	1890	across Canada	competes with native bird species for nesting space
House sparrow *Passer domesticus*	1850	across Canada	competes with native bird species for nesting space

Notes:
1. The quagga mussel is a related species with similar impacts. It is believed to have been introduced to the Great Lakes in the 1980s.
2. See notes on round goby in this table and section 6.5-**Contaminants in biota**.

Sources:
Mosquin, T., P.G. Whiting and D.E. McAllister, 1995, *Canada's Biodiversity: The Variety of Life, Its Status, Economic Benefits, Conservation Costs and Unmet Needs*, Canadian Centre for Biodiversity, Canadian Museum of Nature, Ottawa.
Ontario Federation of Anglers and Hunters.

6.10 Natural disasters

A natural disaster is an extreme natural event—a storm, earthquake, landslide, flood or other incident—that occurs where humans are vulnerable to its effects. Although storms and other extreme natural events originate in the environment, it is often humans who create natural disasters by leaving themselves vulnerable to harm. In developing nations, a combination of poverty and a lack of resources (insufficient land, for example) often prevents individuals from protecting themselves from natural hazards. Even in wealthy nations like Canada, poor planning, inadequate information and blatant disregard for known risks create situations in which people are vulnerable to extreme events. Once in a while, an event of such severity occurs that no amount of foresight, resources or technical know-how will prevent it from becoming a natural disaster.

6.10.1 Natural disasters in Canada

As is seen in section 3.4–**Geophysical and meteorological profile**, different regions of Canada are subject to different natural hazards. Coastal regions are generally exposed to earthquakes, flooding, hurricanes, fog and ice. The country's interior is subject to earthquakes, flooding, tornadoes, hail, landslides, and extremes of hot and cold temperature.

Text Box 6.10.1
The 1988 Drought

The summer of 1988 demonstrated that droughts can be among the most expensive and lethal of natural disasters. One of the hottest and driest summers this century, it brought a drought that led to intensified dust storms, soil erosion and forest fires. Financial losses were estimated to be $1.8 billion (1981 dollars).[1] The drought mainly affected an area from southern Alberta across to southern Ontario. This area was larger than that affected during the Great Depression droughts of 1936 and 1937. In the United States, an estimated 5 000 to 10 000 people died from heat-related stress, and losses were put at US$40 billion (1988 dollars).[2]

1. Wheaton, E.E. and L.M. Arthur (eds.), 1992, *Environmental and Economic Impacts of the 1988 Drought: With Emphasis on Saskatchewan and Manitoba*, Vol. 1, Saskatchewan Research Council Publication No. E-2330-4-E-89, Saskatoon.
2. National Climatic Data Center, 1997, *Billion Dollar U.S. Weather Disasters, 1980-1997*. <http://www.ncdc.noaa.gov/ol/reports/billionz.html>, (accessed December 15, 1997).

Text Box 6.10.2
The 1997 Red River Flood

The Red River, a major north-flowing Manitoba river with a shallow slope, is subject to flooding in the spring like many other North American rivers. The Red River has a recorded history of flooding that dates back to 1776. Flooding was common in the 19th century (including both spring and summer floods), less common during the first half of the 20th century, and then more frequent again, beginning with the catastrophic flood of 1950.

In 1997, the scene was set for a major flood well before the spring, with 300% of normal snowfall in the United States and 200% in Manitoba on top of ground saturated from a wet autumn. Once the flood hit, 1 945 km^2 of land and 2 500 homes were left underwater and 28 000 people were evacuated; about 8 000 military personnel were mobilized to fight the flood. Damages were estimated at approximately $300 million.

Winnipeg was able to avoid major damage from the 1997 flood, in part because of important countermeasures put in place following the 1950 flood—in particular, the Winnipeg floodway, which is capable of diverting 3 690 m^3 of water per second around Winnipeg. The floodway has been used 18 times since its completion in 1968. If it had not been built, the 1997 flood in Winnipeg could have been 1 to 1.3 metres over the level recorded in 1950.

Sources:
International Joint Commission, 1997, *Red River Flooding: Short Term Measures*, Interim Report of the International Red River Basin Task Force to the IJC, Ottawa and Washington.
Pindera, G., 1997, "Red River Dance," in *Canadian Geographic*, Vol. 117, No. 4, pp. 52-62.
University of Manitoba, 1997, *The Flood of the Century: An International Research Workshop,* September 11-12, St. John's College, Winnipeg.

Increasingly, the natural hazards to which Canadians are exposed have combined with areas of vulnerability in the population to create natural disasters. In recent years, disasters have affected some regions of the country severely. Notable examples include the 1988 drought in the Prairies and southern Ontario (Text Box 6.10.1), the 1996 Saguenay region flood (Text Box 3.4.3 in section 3.4–**Geophysical and meteorological profile**), the 1997 Red River flood (Text Box 6.10.2), and the 1998 St. Lawrence River Valley ice storm (Text Box 6.10.3).

As Figure 6.10.1 demonstrates, the number of weather-related disasters in Canada has increased at a more rapid rate than the population since the 1950s. The divergence in these two trends may be due to better reporting of disasters, increased development in regions prone to extreme natural events, increased population density, more frequent extreme events, or any combination of the above.

Text Box 6.10.3
The 1998 St. Lawrence River Valley Ice Storm

From January 4 to 10, 1998, Canada's attention was focussed on a storm that would become the worst freezing rain storm ever to hit the country. The total precipitation,[1] which fell mainly as freezing rain but also as ice pellets and snow, exceeded 73 millimetres in Kingston, Ontario, 85 millimetres in Ottawa, Ontario, and 100 millimetres in areas south of Montréal, Quebec (Map 6.10.1). By comparison, the most severe ice storms previously on record, those of December 1986 in Ottawa and February 1961 in Montréal, left 30 to 40 millimetres of ice, less than half the accumulation of the 1998 storm.

The area covered by freezing rain stretched from Kitchener and Muskoka in southern Ontario, through the Eastern Townships of Quebec, and to the Fundy coasts of New Brunswick and Nova Scotia. Parts of New England and upstate New York in the United States were also severely affected.

In Quebec, 57% of urban areas were subjected to the storm, compared with 15% in Ontario. As Map 6.10.1 indicates, over 18% of Canada's population lives within the area where more than 40 millimetres of freezing rain fell; 11% of Quebec's population was subjected to an accumulation exceeding 80 millimetres. At the height of the storm, close to 1.4 million electricity customers in Quebec and over 230 000 in Ontario were left without power.

Source:
Statistics Canada, 1998, *The St. Lawrence River Valley 1998 Ice Storm: Maps and Facts*, Catalogue No. 16F0021XIB, Ottawa.

1. Measured in equivalent rainfall.

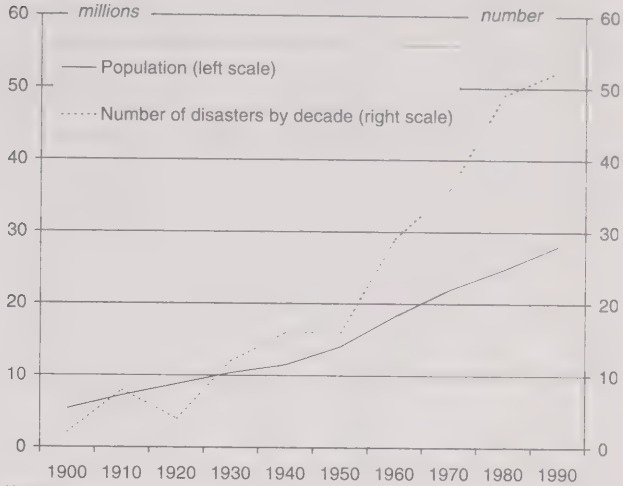
6.10.2 The economic impact of natural disasters

Table 6.10.1 presents the economic impact of some of the major natural disasters throughout Canada's history. As can be seen, droughts have generally been the cause of the greatest economic hardship.

One straightforward means of measuring the economic impact of a natural disaster is to total all the insurance claims made in its wake. In recent years, the number of natural disasters leading to exceptional insurance payments has increased.[1] Between 1983 and 1990, there were 10 disasters, leading to claims totalling $0.5 billion. In contrast, between 1991 and 1998, 42 disasters led to claims totalling $4.6 billion (Table 6.10.2 and Figure 6.10.2).

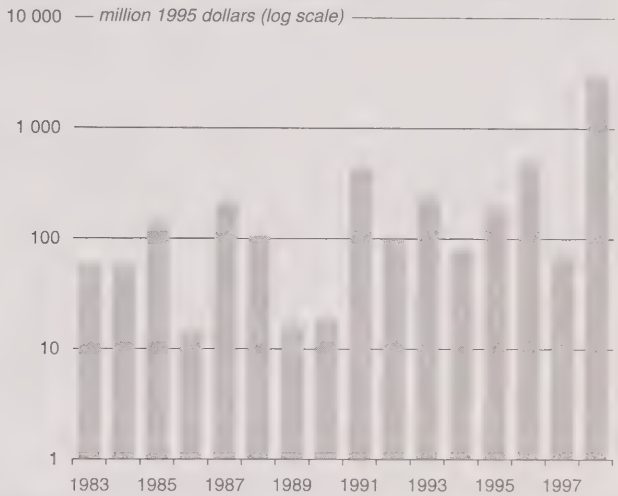
1. In this context, an exceptional insurance payment is defined as one totalling 1% or more of the claims made within a province during a given year.

Figure 6.10.1
Weather-related Disasters and Population by Decade



Notes:
Disaster data points represent the sum of all weather-related disasters in a decade (1900-09, 1910-19, 1920-29, etc.).
Population figures correspond to years 1901, 1911, 1921, etc.
The 1990s disaster data point is estimated based on 1990 to mid-1997 data.
Sources:
Chris Tucker, Emergency Preparedness Canada, personal communication.
Statistics Canada, 1983, *Historical Statistics of Canada*, Second Edition, F.H. Leacy (ed.), Catalogue No. 11-516E, Ottawa.
Statistics Canada, Demography Division.

Figure 6.10.2
Exceptional Insurance Payments Made as a Result of Natural Disasters, 1983-1998



Source:
Insurance Bureau of Canada.

Table 6.10.1
Economic Impact of Selected Natural Disasters in Canada

Date	Natural disaster	Location	Economic impact	Source(s)
September 9-12, 1775	hurricane	Grand Banks, Nfld.	UK£140 000	Nash 1976; Jones 1997; Rappaport and Fernandez-Partagas 1997
June 30, 1912	tornado	Regina, Sask.	$4 million	Etkin and Maarouf 1995
November 18, 1929	tsunami triggered by submarine landslide and earthquake	south coast of Newfoundland, the Burin Peninsula and Nova Scotia	$1-2 million	Clague 1997; Natural Resources Canada
Summer 1936	drought and heat wave	entire country	$514 million (1989 dollars)	Jones 1997; Phillips 1990
Spring 1950	flood	Red River, southern Manitoba	$125.5 million (1957 dollars)	Andrews 1993; Phillips 1990
October 14-16, 1954	hurricane	greater Toronto area	$25 million	Andrews 1993
Summer 1961	drought	Prairie provinces	$668 million (1989 dollars)	Phillips 1990
Summers 1979 and 1980	drought	Prairie provinces	$2.5 billion (1989 dollars)	Phillips 1990
July 28, 1981	hail storm	Calgary, Alta.	$100 million (1989 dollars)	Phillips 1990; Statistics Canada 1994
Summer 1984	drought and heat wave	western provinces	$1 billion	Wheaton and Arthur 1992
May 31, 1985	tornado	southern Ontario	$100 million	Etkin and Maarouf 1995
July 1985	forest fires	British Columbia	$300 million (1989 dollars)	Phillips 1990
July 14, 1987	flood	Montréal, Que.	$229 million	Andrews 1993; Swiss Re Canada 1988
July 31, 1987	tornado	Edmonton, Alta.	$250-300 million (1989 dollars)	Etkin and Maarouf 1995; Phillips 1990
Summer 1988	drought and heat wave	Prairie provinces and Ontario	$1.8 billion (1981 dollars)	Wheaton and Arthur 1992
September 7, 1991	hail storm	Calgary, Alta.	$343 million	Brun 1997
Spring 1993	flood	Winnipeg, Man.	$175 million	Lawford *et al.* 1995
May 1-30, 1995	forest fires	Saskatchewan	$122 million	Swiss Re Canada 1996
September 6, 1995	flood	Alberta and British Columbia	$100 million	Swiss Re Canada 1996
July 16, 1996	hail storm	Calgary, Alta.	$150 million	Brun 1997
July 16, 1996	hail storm	Winnipeg, Man.	$105 million	Brun 1997
July 19-21, 1996	flood	Saguenay region, Que.	$1.5 billion	Etkin 1997; Jones 1997
December 22, 1996 to January 3, 1997	winter storms	British Columbia	$200 million	Environment Canada 1997
May 1997	flood	Red River, southern Manitoba	approximately $300 million	Pindera 1997
January 1998	ice storm and subsequent cold wave	eastern Ontario and southern Quebec	at least $3 billion	Kerry *et al.* 1999; Statistics Canada 1998; Swiss Re Canada 1998

Note:
The main criterion for inclusion of a natural disaster in this table is a significant impact on people.

Sources:

Andrews, J., 1993, *Flooding, Canada Water Book*, Environment Canada, Catalogue No. En 37-96/1993E, Ottawa.
Brun, S.E., 1997, "Atmospheric, Hydrologic and Geophysical Hazards," in Environmental Adaptation Research Group (Environment Canada) and Institute for Environmental Studies (University of Toronto), *Coping with Natural Hazards in Canada: Scientific, Government and Insurance Industry Perspectives*, pp. 15-65, Toronto.
Clague, J.J., 1997, *Tsunamis*, Draft manuscript prepared for the Geological Survey of Canada, National Geological Hazard Synthesis Project, Ottawa.
Environment Canada, 1997, *The Impact of Storm 96*, Pan Pacific Communications Inc., Ottawa.
Etkin, D., 1997, "The Social and Economic Impact of Hydrometeorological Hazards and Disasters: A Preliminary Inventory," in Environmental Adaptation Research Group (Environment Canada) and Institute for Environmental Studies (University of Toronto), *Coping with Natural Hazards in Canada: Scientific, Government and Insurance Industry Perspectives*, pp. 74-110, Toronto.
Etkin, D. and A. Maarouf, 1995, "An Overview of Atmospheric Natural Hazards in Canada," in D. Etkin (ed.), *Proceedings of a Tri-lateral Workshop on Natural Hazards*, pp. I-63 to I-92, Merrickville, Ontario, Feb. 11-14.
Jones, R.L., 1997, "Canadian Disasters - An Historical Survey," in *C.M.O.S. Newsletter*, Vol. 20, No. 5, pp. 10-14, Oct. 1992 (unpublished update by author, October 21, 1997).
Kerry, M., G. Kelk, D. Etkin, I. Burton and S. Kalhok, 1999, *Glazed Over*, Environment Canada, Toronto.
Lawford, R.G., T.D. Prowse, W.D. Hogg, A.A. Warkentin and P.J. Pilon, 1995, "Hydrometeorological Aspects of Flood Hazards in Canada," in *Atmosphere-Ocean*, Vol. 33, No. 2, pp. 303-328.
Nash, J.R., 1976, *Darkest Hours*, Nelson-Hall, Chicago.
Natural Resources Canada, Geomatics Canada, *Natural Hazards*, <http://cgdi.gc.ca/ccatlas/hazardnet/d_tsunami/tsuintro.htm>, (accessed December 22, 1998).
Phillips, D., 1990, *The Climates of Canada*, Environment Canada, Catalogue No. En 56-1/1990E, Ottawa.
Pindera, G., 1997, "Red River Dance," in *Canadian Geographic*, Vol. 117, No. 4, pp. 52-62.
Rappaport, E.N. and J.J. Fernandez-Partagas, 1997, "History of the Deadliest Tropical Cyclones since the Discovery of the New World," in H.F. Diaz and R.S. Pulwarty (eds.), *Hurricanes: Climate and Socioeconomic Impacts*, pp. 93-108, Springer-Verlag, Berlin and Heidelberg.
Statistics Canada, 1998, *The St. Lawrence River Valley 1998 Ice Storm: Maps and Facts*, Catalogue No. 16-F0021XIB, Ottawa.
Statistics Canada, 1994, *Human Activity and the Environment 1994*, Catalogue No. 11-509E, Ottawa.
Swiss Re Canada, 1998, *Inside an Ice Storm*, Swiss Reinsurance Company, Toronto.
Swiss Re Canada, 1996, "Appendix 1: Tables for Report Year 1995," in *Sigma*, No. 2, pp. 17-38, Swiss Reinsurance Company, Toronto.
Swiss Re Canada, 1988, "Statistical Appendix," in *Sigma*, No. 1/2, pp. 13-17, Swiss Reinsurance Company, Toronto.
Wheaton, E.E. and L.M. Arthur (eds.), 1992, *Environmental and Economic Impacts of the 1988 Drought: With Emphasis on Saskatchewan and Manitoba*, Vol. 1, Saskatchewan Research Council Publication No. E-2330-4-E-89, Saskatoon.

Financial assistance to aid the victims of natural disasters can be provided by federal, provincial and, occasionally, municipal governments. The federal government provides assistance when losses exceed $1 per capita in the affected province. It pays for half of the losses between $1 and $3 per capita, for three-quarters of the losses between $3 and $5 per capita, and for 90% of the remainder. Figure 6.10.3 shows federal government disaster assistance payments from fiscal year 1970–71 to fiscal year 1997–98.

Canada also has a public crop insurance program that protects farmers when their crops suffer damage, most often as the result of hail and drought. Crop insurance payments, which are often very large, total approximately $330 million per year. Alberta and Saskatchewan typically receive the bulk of the payments.

Table 6.10.2

Exceptional Insurance Payments Made as a Result of Natural Disasters, 1983-1998[1]

Year	Tornadoes		Hail		Wind		Other storms		Floods		Total	
	Exceptional events	Payouts	Exceptional events	Payouts	Exceptional events	Payouts	Exceptional events	Payouts	Exceptional events	Payouts	Exceptional events	Payouts
	number	million dollars	number	million dollars	number	million dollars	number	million dollars	number	million dollars	number	million dollars
1983	-	-	-	-	-	-	-	-	-	-	1	38
1984	-	-	-	-	-	-	-	-	-	-	1	39
1985	-	-	-	-	-	-	-	-	-	-	1	100
1986	-	-	-	-	-	-	-	-	-	-	1	11
1987	1	148	-	-	-	-	1	21	-	-	2	169
1988	1	50	1	37	-	-	-	-	-	-	2	87
1989	-	-	-	-	-	-	-	-	1	14	1	14
1990	-	-	1	16	-	-	-	-	-	-	1	16
1991	1	39	1	343	2	8	1	28	-	-	5	418
1992	-	-	3	35	3	52	-	-	2	9	8	96
1993	-	-	1	8	-	-	1	18	3	198	5	224
1994	1	12	2	13	-	-	4	40	1	13	8	78
1995	-	-	3	92	-	-	4	87	1	11	8	190
1996	-	-	3	178	-	-	-	-	3	318	6	496
1997[2]	-	-	-	-	-	-	-	-	1	72	1	72
1998[2]	-	-	-	-	-	-	1	3 000	-	-	1	3 000

Notes:
1. An exceptional insurance payout is defined as one totalling 1% or more of claims made within a province during a given year.
2. Includes only those payouts in excess of $20 million.

Source:
Insurance Bureau of Canada.

6.10.3 Natural disasters around the world

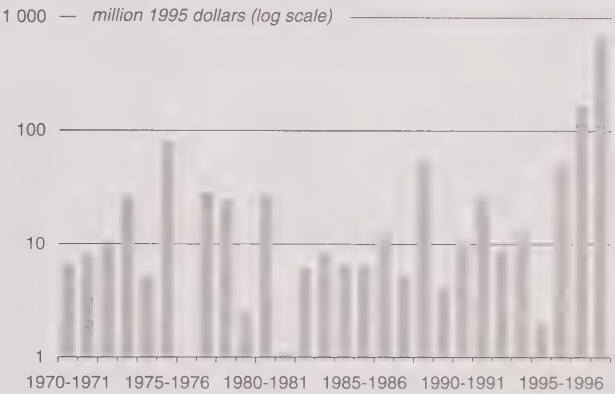
Natural disasters kill approximately one million people per decade around the world. Financial costs have recently surpassed US$100 billion per decade,[1] with losses growing rapidly. Worldwide, the insurance industry had never experienced a single-disaster loss greater than US$1 billion prior to 1988. From 1988 to 1996, there were 15 disasters with losses of more than US$1 billion each. The total economic losses resulting from natural disasters in the 1980s were approximately US$120 billion;[2] this total was surpassed in 1995 when the Hyogo-Ken Nanbu earthquake struck Kobe, Japan, causing approximately US$125 billion in damage.[3]

Recent years have delivered, on average, about one disaster per month, with losses in excess of US$1 billion. In 1998, floods, hurricanes and other natural disasters claimed the lives of about 50 000 people and cost more than US$30 billion.[4]

1. Federal Emergency Management Agency of the United States, 1997, *Report on Costs and Benefits of Natural Hazard Mitigation*, Contract No. 132, Gaithersburg, Maryland.
2. *Ibid.*
3. Kuribayashi, E., M. Kawamura, H. Zhang and Y. Matsui, 1996, "A Comparative Study on Typical Measures of Earthquake Preparedness in Local Governments Between Japan and the USA: Lessons from the Disaster of Japan's Earthquake in Kobe on 17 January, 1995," in C.A. Brebbia (ed.), *The Kobe Earthquake: Geodynamical Aspects*, pp. 111–145, Computational Mechanics Publications, Boston.
4. Reported in *EnviroLine*, 1999, "Cost of Natural Disasters Growing," Vol. 10, No. 6, March 15, p. 6.

Figure 6.10.3

Federal Disaster Payments, 1970-71 to 1997-98



Notes:
Data represent amounts paid to the provinces, or estimates of what the final value might be. Some negotiations are ongoing and, therefore, the figures may change. The number of ongoing negotiations is as follows: 1986(1), 1988(2), 1990(2), 1991(1), 1992(1), 1993(3), 1994(1), 1995(7).
Data for 1996-97 onward are incomplete.

Source:
Emergency Preparedness Canada, 1998, *Tri-Lateral Project on Natural Disasters*, Ottawa.

The Red Cross' *World Disasters Report* provides casualty totals for all disaster events (natural and otherwise) from 1967 to 1991. During this period, 7 766 disasters of all types caused injuries to 2.96 billion people and killed 7.31 million people.[5] Natural disasters accounted for 94% of all injuries, but only 48% of deaths. Table 6.10.3 shows casualties associated with natural disasters around the world between 1980 and 1997.

5. The Red Cross, 1998, *World Disasters Report*, International Federation of Red Cross and Red Crescent Societies, Oxford University Press, Oxford.

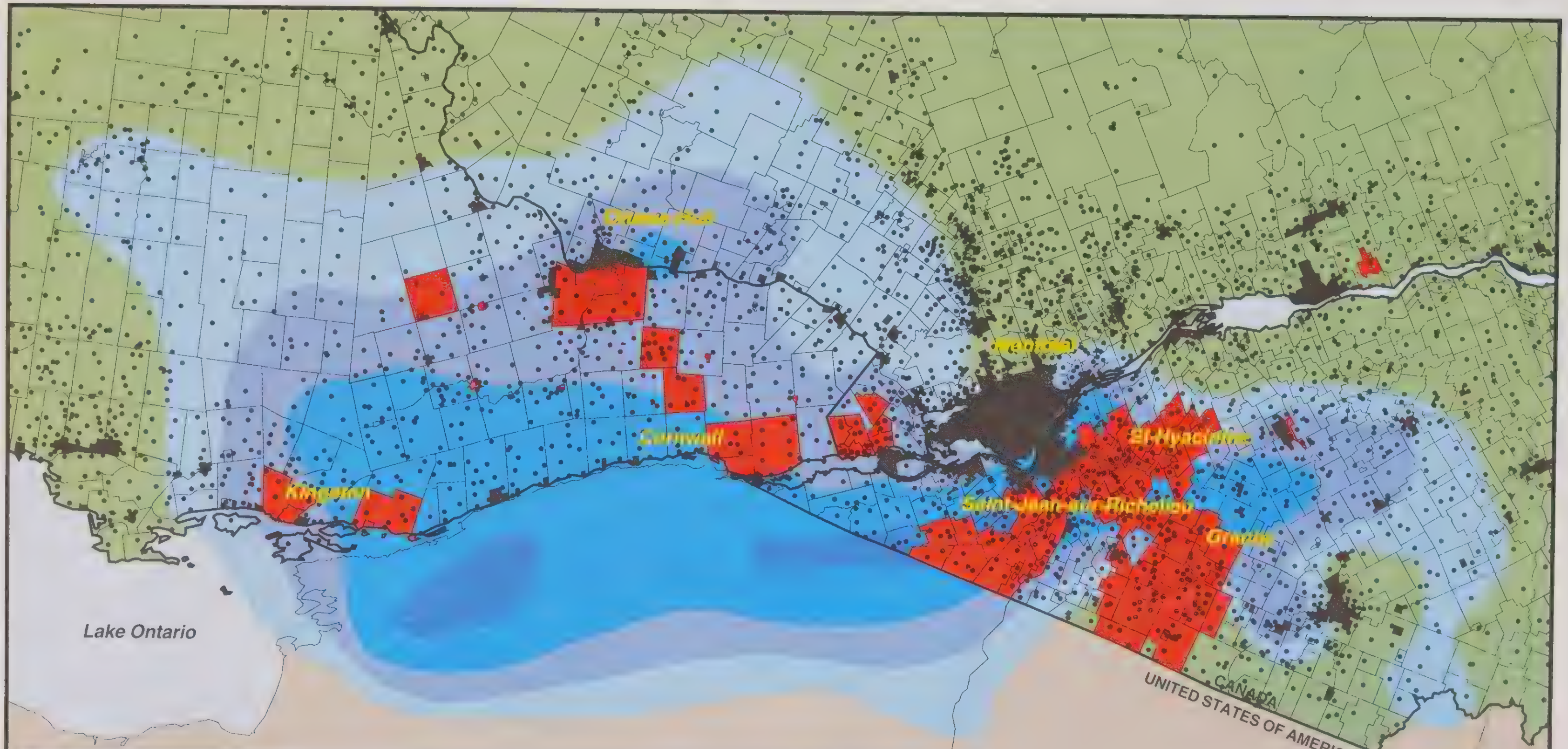
Table 6.10.3
Number of Deaths for Selected Natural Disasters in the World, 1980-1997

Date	Natural disaster	Location	Deaths	Source(s)
October 10, 1980	earthquake	Algeria	2 590	CRED 1998
November 23, 1980	earthquake	Italy	2 614	CRED 1998
July 12-14, 1981	flood	Sichuan, China	more than 1 300	Hewitt 1997; Davis 1992
September 1982	flood	Orissa, India	more than 1 000	Hewitt 1997
1983-88	drought	Ethiopia	more than 1 000 000	Hewitt 1997; Davis 1992; CRED 1998
January 1984	drought	Sudan	150 000	CRED 1998
January 1985	drought	Mozambique	100 000	CRED 1998
May 1985	cyclone	Bangladesh and Pakistan	100 000	Bryant 1991
September 18-19, 1985	earthquake	Mexico City	8 776	Hewitt 1997; CRED 1998
November 13, 1985	lahars (mudflows) from the eruption of Nevado del Ruiz	Colombia	23 000	National Geographic 1997
August 21, 1986	toxic gas release	Lake Nyos, northwest Cameroon	1 746	Musa 1998
October 10,1986	earthquake	El Salvador	1 000	CRED 1998
March 6, 1987	earthquake	Ecuador	4 000	CRED 1998
August 21, 1988	earthquake	India and Nepal	more than 1 100	Hewitt 1997; Davis 1992
September-November 1988	flood	Bangladesh	2 100	Davis 1992
July 14, 1989	flood	China	2 000	CRED 1998
June 21, 1990	earthquake	Iran	40 000	Hewitt 1997
July 16, 1990	earthquake	Philippines	1 660	CRED 1998
February 4, 1991	earthquake	Afghanistan	1 200	CRED 1998
May 18, 1991	flood	China	1 729	CRED 1998
June 1991	flood	Afghanistan	more than 5 000	Hewitt 1997
July 28, 1991	earthquake	Iran	1 200	CRED 1998
August 3, 1991	drought	China	2 000	CRED 1998
October 20, 1991	earthquake	India	1 500	CRED 1998
September 1992	flood	Pakistan	more than 2 000	Hewitt 1997
July 1993	flood	Nepal, India and Bangladesh	4 000	Hewitt 1997
September 30, 1993	earthquake	India	7 600	Hewitt 1997; CRED 1998
June 1994	flood	southern China	1 400	Hewitt 1997
January 17, 1995	earthquake	Kobe, Japan	5 500	Hewitt 1997
May 27, 1995	earthquake	Russia	1 989	CRED 1998
July 4, 1995	flood	China	1 400	CRED 1998
May 10, 1997	earthquake	Iran	1 728	CRED 1998
October 25, 1997	flood	Somalia	2 311	CRED 1998

Note:
The main criterion for inclusion of a natural disaster in this table is significant impact on people.
Sources:
Bryant, E., 1991, *Natural Hazards*, Cambridge University Press, Cambridge.
Centre for Research on the Epidemiology of Disasters (CRED), 1998, Université Catholique de Louvain, Brussels.
Davis, L.A., 1992, *Natural Disasters: From the Black Plague to the Eruption of Mt. Pinatubo*, New York.
Hewitt, K., 1997, *Regions of Risks: A Geographic Introduction to Disasters*, Addison Wesley Longman Ltd, Harlow, England.
Musa, T., 1998, "Tanker Explosion Claims 120 Lives," reported in *The Globe and Mail*, February 16, 1998, p. A10.
National Geographic, 1997, *Our Restless Earth*, National Geographic Society, Washington.

Map 6.10.1

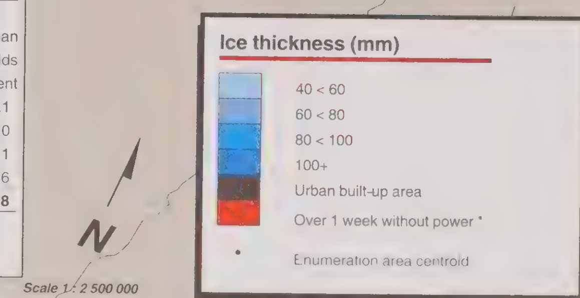
Population and Power Failure, St. Lawrence River Valley Ice Storm, 1998



Population and Households Affected by the Storm

Ice thickness	Population			As share of Canadian population	Households			As share of Canadian households
	Quebec	Ontario	Total		Quebec	Ontario	Total	
millimetres	persons			percent	persons			percent
40 < 60	1 358 590	94 619	1 453 209	5.0	521 029	36 181	557 210	5.1
60 < 80	1 922 646	951 230	2 873 876	10.0	831 402	367 836	1 199 238	11.0
80 < 100	665 670	225 678	891 348	3.1	254 108	84 844	338 952	3.1
100+	185 852	-	185 852	0.6	64 979	-	64 979	0.6
Total	**4 132 758**	**1 271 527**	**5 404 285**	**18.7**	**1 671 518**	**488 861**	**2 160 379**	**19.8**

Sources:
Environment Canada, Atmospheric Environment Service, Toronto
Statistics Canada, Environmental Accounts and Statistics Division.



* *Sources: Hydro-Québec and Municipal Electric Association*

Source:
Statistics Canada, 1998, *The St. Lawrence River Valley 1998 Ice Storm: Maps and Facts*, Catalogue No. 16F0021XIB, Ottawa.

7 Responses and Participation

Introduction

Society's awareness of the negative effects of its activities on human health and on ecosystems has prompted governments, businesses and citizens to act in different ways.

Some view maintaining or improving our environment as costly to both industries and households. However, we can achieve economic benefits through sound environmental practices (such as increased energy efficiency) and the development of 'green' products.

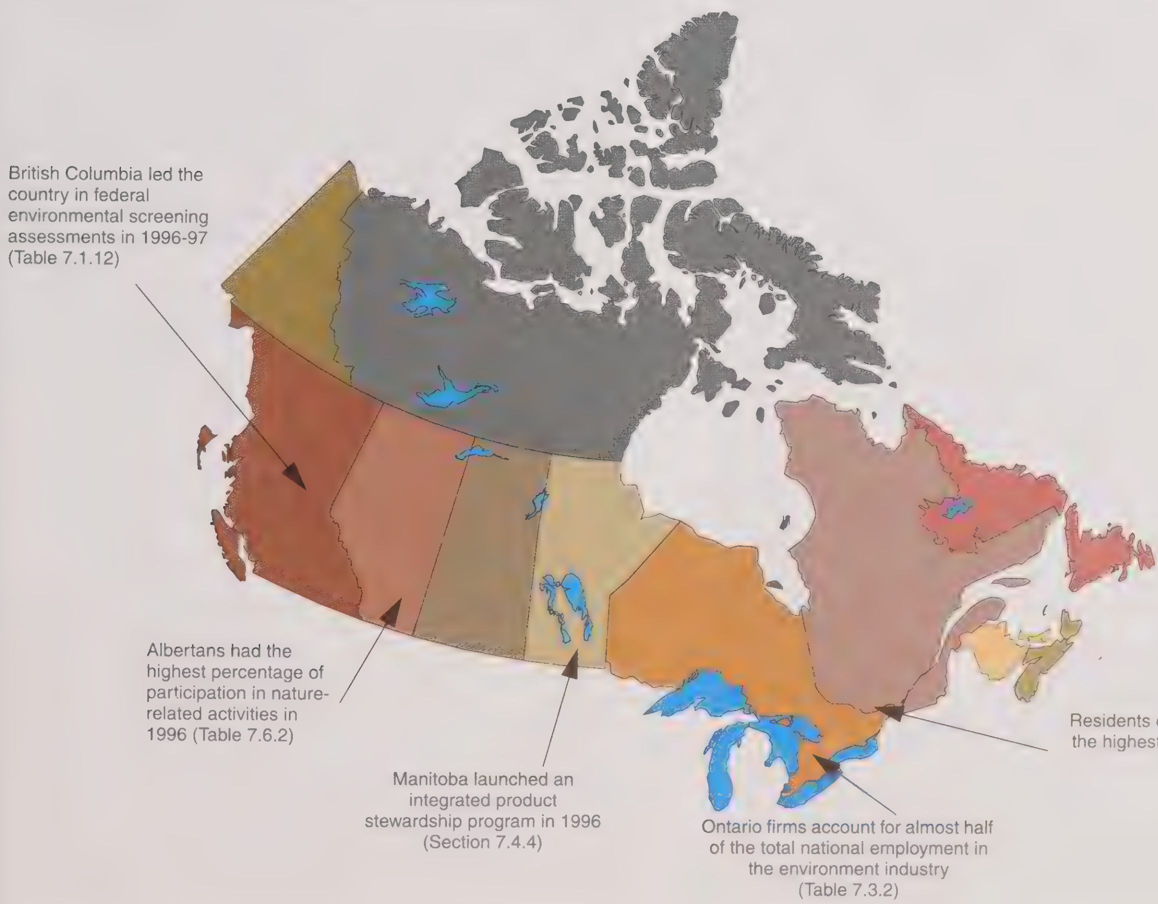
This chapter describes the main responses by governments, companies and households aimed at minimizing or reducing the harmful effects of human activity on the environment.

Environmental legislation and non-regulatory initiatives: Legislation is one of the main ways that governments encourage environmental protection. The *Canadian Environmental Protection Act* (CEPA) is an example of Canadian legislation pertaining to health and the environment.

However, the legislative framework instituted between 1970 and 1990 now gives even more room for another type of action—the non-regulatory environmental initiative. Governments, industries and other non-governmental players jointly undertake such initiatives.

Environmental protection expenditures: The effectiveness of environmental protection activities can be assessed from the amount of money society spends to prevent and reduce the effects of human activity on the environment. Such expenditures indicate the demand for environmental goods and services and the impact of this demand on the Canadian economy.

Map 7.1
Responses and Participation Highlights



In 1996 the various levels of government invested $5.4 billion in setting up and applying environmental antipollution regulations. That same year companies invested $4.9 billion in various environmental protection activities, particularly waste management, environmental project assessments and waste reduction.

The environment industry: Innovative solutions to environmental problems can create large markets for Canadian businesses, both domestically and internationally.

In 1995, the production of environmental goods and services resulted in $10.2 billion in revenue for these businesses. In addition, 150 000 jobs were created, many of them related to environmental production.

Environmental practices: Agreements like Accelerated Reduction/Elimination of Toxics (ARET) and environmental regulations like those of the *Canadian Environmental Protection Act* (CEPA) and national and international product standards and guidelines have resulted in the development of various governmental and industrial practices aimed at preventing or reducing degradation of the environment.

Examples of such practices include reuse and recycling programs, research and development (R&D) in environmental and energy-efficiency fields, and the implementation of technologies aimed at reducing air, soil and water pollution or at minimizing the use of natural materials and resources.

Public participation: One way for individuals to help to protect the environment is to devote money or time to non-governmental environmental organizations. Other forms of proactive participation include using automobiles less, adopting energy-efficient practices at home, taking part in recycling programs and purchasing green products. Individuals can play a role in the environmental policy-making process through public hearings and consultations, such as environmental assessments.

Recreation: Public use of parks and the popularity of nature observation activities, hunting and fishing reflect the importance of nature to Canadians.

Environmental education: The ultimate example of public awareness of and participation in environmental protection can be seen in environmental educational programs in schools, colleges and universities.

7.1 Environmental legislation and non-regulatory initiatives

Canadians are concerned about the state of the environment (see section 7.5–**Public participation**). To address this concern, governments in Canada have identified a sustainable development goal: resources are to be used in ways that do not deteriorate the environment for future generations. One of the strongest actions taken by government is the creation of legislation that promotes responsible and sustainable resource use by industry and individuals. Both governments and the private sector are making increasing use of non-regulatory initiatives to address environmental issues (Text Box 7.1.1).

Text Box 7.1.1

Evolution of National Environmental Initiatives, 1970s to 1990s

1970s: Environmental issues

- creation of the federal Department of the Environment (now Environment Canada)
- Conservation in Canada Report (following the 1972 United Nations Conference on the Human Environment)
- Canada as a conserver society: resource uncertainties and the need for new technologies (1977)
- Strategy for National Parks

1980s: Environmental planning

- sectoral environmental policy/legislation
- Brundtland Commission on Sustainable Development
- National Task Force on the Environment and the Economy
- round tables on the environment and the economy

1990s: Sustainable development

- Green Plan
- Agenda 21
- Harmonization Accord
- pollution prevention
- revision of the *Canadian Environmental Protection Act*
- voluntary programs

7.1.1 Co-operation between federal, provincial and territorial governments

Provincial, territorial and federal governments co-operate in addressing environmental issues since they share environmental jurisdiction. Intergovernmental councils address problems associated with shared jurisdictions.

The Canadian Council of Ministers of the Environment (CCME) is the main council co-ordinating federal, provincial and territorial policies on the environment. The Environmental Harmonization Accord is one of the CCME's main initiatives to improve intergovernmental co-operation (Text Box 7.1.2). Other councils that deal with environmental issues and legislation, but are not part of the CCME, include

- the Wildlife Ministers' Council of Canada;
- the Federal–Provincial Parks Council;

Text Box 7.1.2

Environmental Harmonization Accord

What is it?

The Environmental Harmonization Accord, signed on January 29, 1998, is an agreement that Canada's governments will work together to set standards for the environment. Each government retains its existing authority but will use the standards in a co-ordinated effort.[1]

Why is it needed?

Traditionally, federal, provincial and territorial governments developed their own standards for the environment. This meant that some provinces had lower standards than others. Environmental problems such as climate change and ozone depletion need the co-operation of all governments, however, to reduce their environmental impacts. This accord sets a minimum set of standards for all of Canada.

The Accord sets national standards for

- ground-level ozone (smog);
- dioxins and furans in all media (water, soil, air);
- particulate matter in air;
- mercury in all media (water, soil, air);
- benzene in air; and
- petroleum hydrocarbons in soil.

1. The province of Quebec has not signed the accord.

- the Canadian Council of Forest Ministers;
- the Canadian Council of Energy Ministers;
- the Federal, Provincial and Territorial Agricultural Ministers and Deputy Ministers Conference; and
- the National Climate Change Secretariat.

7.1.2 Environmental legislation

Legislation has been developed by the federal, provincial and territorial governments to address a number of environmental issues in Canada. Generally, this legislation falls into the following categories:

- generic environmental legislation;
- legislation on environmental protection;
- legislation on natural resources;
- legislation on pollution; and
- environmental impact assessment legislation.

Generic environmental legislation

Generic environmental legislation often addresses several environmental issues for federal, provincial and territorial governments (Table 7.1.1). The *Canadian Environmental Protection Act* (CEPA) is the main piece of generic environmental legislation establishing environmental rights and responsibilities at the national level. In 1988, this legislation consolidated the *Clean Air Act*, the *Canada Water Act*, the *Environmental Contaminants Act,* the *Ocean Dumping Control Act* and the *Department of the Environment Act* into one central act. A new CEPA is currently in the making to reflect changing environmental challenges and social goals (Text Box 7.1.3).

Table 7.1.1
Generic Environmental Legislation by Jurisdiction

Jurisdiction	Legislation
Federal	Canadian Environmental Protection Act
Newfoundland	Department of Environment and Lands Act
Prince Edward Island	Environmental Protection Act
Nova Scotia	Environment Act
New Brunswick	Clean Environment Act
Quebec	Environment Quality Act
Ontario	Environmental Protection Act
Manitoba	Environment Act
Saskatchewan	Environmental Management and Protection Act
Alberta	Environmental Protection and Enhancement Act and Regulations
British Columbia	Environment Management Act
Yukon Territory	Environment Act
Northwest Territories	Environmental Protection Act

Source:
Canadian Environmental Directory 1997/98, Seventh Edition, Copp Clark Professional, Toronto.

Text Box 7.1.3
A 'New' *Canadian Environmental Protection Act* (CEPA)

CEPA became law in 1988 and is now being reviewed. The review identifies 141 recommendations for improvements to the Act.

The Act covers

- pollution prevention;
- management of toxic substances;
- clean air and water—fuels, vehicle emissions and international air and water pollution;
- control of pollution and wastes—land-based sources of marine pollution, disposal at sea and movement of hazardous and non-hazardous wastes and recyclable materials;
- environmental matters related to emergencies;
- biotechnology;
- federal government operations and federal and Aboriginal lands;
- enforcement;
- information gathering, objectives, guidelines and codes of practice; and
- public participation.

Some new features of the Act are

- linkages between the environment and health;
- consideration of biotechnology issues;
- increased powers to regulate energy and fuel efficiency;
- regulation of a tradable emissions credit system;
- greater control of toxic substances and virtual elimination of persistent toxic substances;
- proactive planning for pollution prevention, including powers to require pollution prevention, planning for substances declared toxic under CEPA and an awards program to recognize voluntary pollution prevention efforts;
- the right of citizens to sue;
- improved federal enforcement through expanded powers for inspectors and the creation of a CEPA investigator with additional powers to investigate suspected offences;
- inclusion of Aboriginal peoples in environmental protection;
- intergovernmental co-operation through federal-provincial harmonization;
- provisions to encourage more Canadians to report CEPA violations; and
- new instruments for information sharing, including an internet-based pollution prevention 'clearinghouse' and an Internet-based environmental registry at <http://www.ec.gc.ca/cppic>.

Sources:
Templegate Information Service and Environment Canada.

Legislation on environmental protection

Environmental legislation is often focused on specific environmental components. Collectively, physical components such as land, air and water (Table 7.1.2) and biotic components like wildlife, plants and domesticated animals (Table 7.1.3) represent the biophysical characteristics of the environment.

Provincial and territorial jurisdiction over property and resource management gives the provinces and territories considerable powers in legislating the biophysical components of the environment. The federal government, however, retains specific powers under its jurisdiction on those federal and First Nations lands within provincial/territorial borders and particularly over those issues that have interprovincial or international consequences.

Table 7.1.2
Federal, Provincial and Territorial Environmental Legislation on Physical Components

Topic	Jurisdiction	Legislation
Land and related flora	Federal	National Parks Act; National Battlefields at Québec Act; James Bay and Northern Quebec Native Claims Settlement Act; National Housing Act and Regulations; Territorial Lands Act and Regulations; Canada Lands Survey Act; Indian Act; Territorial Lands Act; Yukon Act; Yukon First Nations Land Claims Settlement Act; Indian Lands Agreement (1986) Act; Railway Belt Act; Railway Belt and Peace River Block Act, Caughmawaga Indian Reserve Act; Gwichiin Land Claim Settlement Act; Land Titles Repeal Act; New Brunswick Indian Reserves Agreement Act; Nunavut Act; Nunavut Land Claims Agreement Act; Saskatchewan Treaty Land Entitlement Act; Songhees Indian Reserve Act; Waterton Glacier International Peace Park; Western Arctic (Inuvialuit) Claims Settlement Act; Prairie Farm Rehabilitation Act
	Newfoundland	Municipalities Act; Environmental Assessment Act; Wilderness and Ecological Reserves Act; Crown Lands Act; Lands Act
	Prince Edward Island	Planning Act; National Park Act; Recreational Development Act; Land Protection Act; Municipalities Act; Roads Act; Weed Control Act
	Nova Scotia	Planning Act; Environmental Trust Act; Provincial Parks Act; Towns Act; Municipal Act; Parks Development Act, Agriculture and Marketing Act; Weed Control Act; Beaches Act; Crown Lands Act; Mineral Resources Act; Conservation Easement Act; Environmental Assessment Act
	New Brunswick	Marshland Reclamation Act; Parks Act; Mining Act; Weed Control Act; Ecological Reserves Act; Community Planning Act; Crown Lands and Forest Act; Agricultural Land Protection and Development Act
	Quebec	Preservation of Agricultural Lands Act; Land Use Planning and Development Act; Parks Act; Ecological Reserves Act; Lands in the Public Domains Act; Agriculture Abuses Act; Cities and Towns Act
	Ontario	Drainage Act; Mining Act; Public Lands Act; Weed Control Act; Topsoil Preservation Act; Shoreline Property Assistance Act; Niagara Escarpment Planning and Development Act; Planning Act; Aggregate Resources Act; Conservation Authorities Act; Provincial Parks Act; Municipal Act; Environmental Assessment Act
	Manitoba	Crown Lands Act; Planning Act; Municipal Act; Mines Act; Provincial Park Lands Act; Ecological Reserves Act; Noxious Weeds Act; Manitoba Habitat Heritage Act; Heritage Resources Act; Conservation Districts Act
	Saskatchewan	Planning and Development Act; Provincial Lands Act; Critical Wildlife Habitat Act; Rural Municipalities Act; Conservation and Development Act; Prairie and Forest Fires Act; Regional Parks Act; Environmental Assessment Act; Ecological Reserves Act; Parks Act; Environmental Management and Protection Act; Noxious Weeds Act
	Alberta	Surface Rights Act; Soil Conservation Act; Boundary Surveys Act; Land Agents Licensing Act; Land Surveyors Act and Regulations; Provincial Parks Act and Regulations; Public Lands Act and Regulations; Special Areas Act; Surveys Act and Regulations; Wilderness Area, Ecological Reserves and Natural Areas Act; Willmore Wilderness Park Act; Special Areas Act
	British Columbia	Agricultural and Rural Development Act; Soil Conservation Act; Mineral Land Tax Act; Mineral Tenure Act and Regulations; Mining Right of Way Act; Boundary Act; Ecological Reserves Act and Regulations; Environment and Land Use Act; Greenbelt Act; Land Act; Land Settlement and Development Act; Land Survey Act; Land Surveyors Act; Land Title Act
	Yukon Territory	Environment Act; Lands Act and Regulations; Parks Act; Municipal Act
	Northwest Territories	Commissioner's Land Act; Planning Act; Territorial Parks Act; Cities, Towns and Villages Act; Environmental Protection Act
Water	Federal	Canada Water Act; Fisheries Act; Territorial Lands Act; Arctic Waters Pollution Prevention Act; Canadian Environmental Protection Act; Navigable Waters Protection Act; Canada Shipping Act; Coastal Fisheries Protection Act and Regulations; International Boundary Waters Treaty Act; Railway Act; Yukon Waters Act; Northwest Territories Waters Act
	Newfoundland	Aquaculture Act; Waters Protection Act; Well Drilling Act
	Prince Edward Island	Municipalities Act; Water and Sewerage Act
	Nova Scotia	Environment Act; Water Resources Agreement Act; Irish Moss Act; Parks Development Act; Towns Act; Aquaculture Act
	New Brunswick	Irish Moss Act; Pesticides Control Act; Aquaculture Act; Clean Water Act; Drainage of Farmlands Act
	Quebec	Environmental Quality Act; Water Courses Act; Commercial Fisheries and Aquaculture Act; Mining Act
	Ontario	Drainage Act; Public Utilities Act; Environmental Protection Act; Ontario Water Resources Act; Water Transfer Control Act; Tile Drainage Act
	Manitoba	Water Supply Commission Act; Water Rights Act and Regulations; Water Resources Administration Act; Water Power Act
	Saskatchewan	Water Resources Management Act; Water Appeal Board Act; Ground Water Conservation Act; Water Corporation Act; Drainage Act
	Alberta	Clean Water Act; Water Act; Water Resources Commission Act; Drainage Districts Act and Regulations; Environmental Protection and Enhancement Act; Hydro and Electric Energy Act
	British Columbia	Water Act and Regulation; Water Protection Act; Water Utility Act; Drainage Ditch and Dyke Act; Dyke Maintenance Act; Dyking Authority Act; Fisheries Act; Health Act; Libby Dam Reservoir Act; Riverbank Protection Act; Flood Relief Act and Regulations
	Yukon Territory	Environment Act; Municipal Act; Freshwater Fisheries Agreement Act
	Northwest Territories	Water Resources Agreement Act; Freshwater Fish Marketing Act; Environmental Protection Act
Air	Federal	Canadian Environmental Protection Act
	Newfoundland	Environment Act
	Prince Edward Island	Environment Protection Act; Highway Traffic Act
	Nova Scotia	Ozone Layer Protection Act; Motor Vehicle Act; Environmental Protection Act
	New Brunswick	Clean Environment Act
	Quebec	Environmental Quality Act; Acid Rain Act
	Ontario	Environmental Protection Act; Farm Practices Protection Act; Highway Traffic Act
	Manitoba	Environment Act; Public Health Act; Ozone-Depleting Substances Act and Regulations
	Saskatchewan	Clean Air Act; Ozone Depleting Substances Control Act
	Alberta	Clean Air Act; Environmental Protection and Enhancement Act
	British Columbia	Waste and Air Management Act; Environmental Protection Act; Weather Modification Act; Motor Vehicle Act
	Yukon Territory	Environment Act
	Northwest Territories	Environmental Protection Act

Source:
Canadian Environmental Directory 1997/98, Seventh Edition, Copp Clark Professional, Toronto.

Table 7.1.3
Federal, Provincial and Territorial Environmental Legislation on Wildlife, Plants and Domesticated Animals

Jurisdiction	Legislation
Federal	Canada Wildlife Act; Canada Endangered Species Act; Migratory Birds Convention Act; National Wildlife Week Act; Wild Animal and Plant Protection and Regulation of International and Interprovincial Trade Act (WAPPRIITA)
Newfoundland	Animal Protection Act; Plant Protection Act; Wilderness and Ecological Reserves Act; Wildlife Act
Prince Edward Island	Fish and Game Protection Act; Natural Areas Protection Act; Forest Management Act
Nova Scotia	Wildlife Act and Regulations; Irish Moss Act; Crown Lands Act; Provincial Parks Act; Environmental Trust Act; Agriculture and Marketing Act; Parks Development Act; Angling Act
New Brunswick	Fish and Wildlife Act; Endangered Species Act and Regulations
Quebec	Threatened or Vulnerable Species Act; Tree Protection Act; Ecological Reserves Act; Plant Protection Act; Hunting and Fishing Rights Act; Conservation and Development of Wildlife Act
Ontario	Game and Fish Act; Endangered Species Act
Manitoba	Wildlife Act and Regulations; Endangered Species Act; Ecological Reserves Act; Heritage Resources Act; Provincial Park Lands Act
Saskatchewan	Critical Wildlife Habitat Act; Wildlife Act; Ecological Reserves Act; Fisheries Act
Alberta	Agricultural Pests Act; Wildlife Act and Regulations; Wilderness Areas, Ecological Reserves and Natural Areas Act; Provincial Parks Act
British Columbia	Wildlife Act; Creston Valley Wildlife Act; Dogwood, Rhododendron and Trillium Protection Act; Park Act; Plant Protection Act; Ecological Reserve Act
Yukon Territory	Wildlife Act and Regulations
Northwest Territories	Wildlife Act and Regulations

Source:
Canadian Environmental Directory 1997/98, Seventh Edition, Copp Clark Professional, Toronto.

The federal government legislates transportation including railroads, aviation and shipping because of the potential transboundary implications for the environment. The federal government is also responsible for the land component of nationally significant landscapes and important wildlife habitats. Many issues related to seacoasts and inland fisheries also fall under federal jurisdiction. Similarly, air pollution is a transboundary issue for the federal government to address. Any wildlife species that is migratory, such as fish, marine mammals and other ocean species, is also the responsibility of the federal government, as are threatened species of national significance.

Legislation on natural resources

Resource sector legislation deals with specific natural resources and any related human activities. The agriculture, forestry, fisheries and energy sectors are all legislated to some degree (Table 7.1.4).

Provinces and territories have jurisdiction over resource-based industries. However, the fisheries industry involves a resource that can move between provincial and international boundaries and is therefore primarily under federal jurisdiction. Similarly, the federal government legislates international and interprovincial energy matters for those projects on federal lands, or for those requiring federal

Table 7.1.4
Federal, Provincial and Territorial Environmental Legislation on Natural Resources

Topic	Jurisdiction	Legislation
Agriculture	Federal	Fertilizers Act and Regulations; Pest Control Products Act and Regulations; Pesticide Residue Compensation Act; Plant Protection Act; Prairie Farm Rehabilitation Act
	Newfoundland	Pesticides Control Act and Regulations; Animal Protection Act; Livestock Act and Regulations; Plant Protection Act
	Prince Edward Island	Animal Health and Protection Act; Pesticides Control Act and Regulations; Plant Health Act; Weed Control Act
	Nova Scotia	Animal Health and Protection Act and Regulations; Livestock Health Services Act; Marshland Reclamation Act; Weed Control Act; Wildlife Act
	New Brunswick	Agricultural Development Act; Agricultural Land Protection and Development Act; Agricultural Operations Practices Act; Agricultural Rehabilitation and Development Act; Diseases of Animals Act; Drainage of Farmlands Act; Injurious Insects and Pest Act; Marshland Reclamation Act; Pesticide Control Act and Regulations; Plant Diseases Act; Weed Control Act
	Quebec	Act to Preserve Agricultural Lands; Act respecting the Ministère de l'Agriculture, des Pêcheries et de l'Alimentation; Act respecting Public Agricultural Lands in the Public Domain; Agricultural Abuses Act; Animal Health Protection Act; Plant Protection Act
	Ontario	Agricultural Rehabilitation and Development Act; Ontario Tile Drainage Installation Act; Drainage Act; Farm Practices Protection Act; Plant Diseases Act; Tile Drainage Act; Topsoil Preservation Act; Weed Control Act
	Manitoba	Animal Diseases Act; Crown Land Act; Farm Lands Ownership Act and Regulations; Farm Practices Protection Act and Regulations; Land Rehabilitation Act; Noxious Weeds Act and Regulations; Pesticides and Fertilizers Control Act; Plant Pests and Diseases Act and Regulations; Wildlife Act
	Saskatchewan	Agri-food Act; Animal Protection Act; Diseases of Animals Act; Drainage Act; Expropriation Act; Grain and Fodder Conservation Act; Noxious Weeds Act; Pest Control Act; Pest Control Products Act and Regulations; Pollution Control Act; Provincial Lands Act; Soil Drifting Control Act; Wildlife Act
	Alberta	Agricultural Operations Practices Act; Agricultural Pests Act; Animal Protection Act; Irrigation Act; Livestock Diseases Act; Soil Conservation Act; Surface Rights Act; Weed Control Act and Regulations
	British Columbia	Agricultural Land Commission Act; Agricultural and Rural Development Act; Animal Disease Control Act and Regulations; Farming and Fishing Industries Development Act; Grasshopper Control Act; Livestock Protection Act; Plant Protection Act; Soil Conservation Act; Weed Control Act and Regulations
	Yukon Territory	Lands Act and Regulations; Agriculture Development Act; Environment Act
	Northwest Territories	Pesticide Act and Regulations

Table 7.1.4
Federal, Provincial and Territorial Environmental Legislation on Natural Resources (continued)

Topic	Jurisdiction	Legislation
Fish	Federal	Atlantic Fisheries Restructuring Act; Coastal Fisheries Protection Act and Regulations; Fisheries Act; Fish Inspection Act; Fisheries Development Act; Fishing and Recreational Harbours Act; Freshwater Fish Marketing Act; Great Lakes Fisheries Convention Act; Oceans Act; Territorial Sea and Fishing Zones Act
	Newfoundland	Aquaculture Act and Regulations; Department of Fisheries Act; Fish Inspection Act and Regulations; Fisheries Restructuring Act
	Prince Edward Island	Fish and Game Protection Act; Fish Inspection Act
	Nova Scotia	Aquaculture Act; Fisheries Act; Fisheries Development Act; Irish Moss Act; Sea Plants Harvesting Act
	New Brunswick	Aquaculture Act; Fish Inspection Act; Fisheries Development Act
	Quebec	Commercial Fisheries and Aquaculture Act; Act respecting the Ministère de l'Agriculture, des Pêcheries et de l'Alimentation
	Ontario	Fish Inspection Act; Game and Fish Act; Beds of Navigable Waters Act
	Manitoba	Fisheries Act; Fisherman's Assistance and Polluter's Liability Act
	Saskatchewan	Fisheries Act
	Alberta	Fish Marketing Act and Regulations
	British Columbia	Farming and Fishing Industries Development Act; Fish Inspection Act
	Yukon Territory	Freshwater Fisheries Agreement Act
	Northwest Territories	Freshwater Fish Marketing Act
Forest	Federal	Territorial Lands Act; The Canada Forestry Act; Forestry Development and Research Act
	Newfoundland	Plant Protection Act; Forest Protection Act; Department of Forestry and Agriculture Act
	Prince Edward Island	Forest Management Act; Fire Prevention Act
	Nova Scotia	Forests Act and Regulations; Forest Enhancement Act; Environmental Trust Act; Crown Lands Act
	New Brunswick	Plant Diseases Act; Crown Lands and Forests Act; Forest Fires Act; Forest Products Act; Injurious Insect and Pest Act; Maritime Forestry Complex Corporation Act
	Quebec	Preservation of Agricultural Land Act; Plant Protection Act; Forest Act; Tree Protection Act; Act respecting the Société québécoise de récupération et de recyclage
	Ontario	Forestry Act; Forest Tree Pest Control Act; Crown Timber Act; Forest Fires Prevention Act; Plant Disease Act; Algonquin Forestry Authority Act
	Manitoba	Forest Act; Fires Prevention Act; Dutch Elm Disease Act
	Saskatchewan	Forest Act; Prairie and Forest Fires Act
	Alberta	Forests Act; Forest Reserves Act and Regulations; Forest and Prairie Protection Act
	British Columbia	BC Forests Renewal Act; Beaver Lodge Lands Trust Renewal Act; Boom Chain Brand Act; Carmanah Pacific Park Act; Forest Act; Forest Land Reserve Act; Forest Practices Code of British Columbia Act; Forest Stand Management Act; Foresters Act; Ministry of Forests Act; Range Act and Regulations; South Moresby Implementation Account Act
	Yukon Territory	Forest Protection Act and Regulations; Lands Act and Regulations
	Northwest Territories	Forest Protection Act; Forests Management Act and Regulations
Energy	Federal	Atomic Energy Control Act; Canada-Newfoundland Atlantic Accord Implementation Act; Canada-Nova Scotia Offshore Petroleum Resources Accord; Canada Petroleum Resources Act; Canadian Exploration and Development Incentives Program Act; Canadian Exploration Incentive Program Act; Cooperative Energy Act; Energy Efficiency Act and Regulations; Energy Administration Act and Regulations; Energy Monitoring Act and Regulations; Energy Supplies Emergency Act; Hibernia Development Project Act; Home Insulation Program Act; National Energy Board Act and Regulations; Nuclear Liability Act; Oil Substitution and Conservation Act and Regulations; Petroleum Incentives Program Act and Regulations
	Newfoundland	Canada-Newfoundland Atlantic Accord Implementation Act; Department of Mines and Energy Act; Electrical Power Control Act; Emergency Measures Act; Federal-Provincial Power Act; Lower Churchill Development Act; Mineral Act and Regulations; Mineral Lands Act; Mineral Vesting in the Crowns Act; Newfoundland and Labrador Power Commission Act; Newfoundland and Labrador Rural Electricity Act; Petroleum Corporation Act; Petroleum and Natural Gas Act; Quarry Materials Act and Regulations; Regulations of Mines Act; Rural Electrification Act; Undeveloped Minerals Area Act
	Prince Edward Island	Electric Power and Telephone Act; Energy Corporation Act; Mineral Resources Act; Oil and Natural Gas Act; Petroleum Products Act; Recreational Development Act
	Nova Scotia	Canada-Nova Scotia Offshore Petroleum Resources Accord; Energy and Mineral Resources Conservation Act; Energy-Efficient Appliances Act and Regulations; Gas Storage Exploration Act and Regulations; Mineral Resources Act; Petroleum Resources Act; Public Utilities Act
	New Brunswick	Bituminous Shale Act; Energy Efficiency Act; Gas Distribution Act; Mining Act; Oil and Natural Gas Act; Ownership of Minerals Act; Pipeline Act; Quarriable Substances Act
	Quebec	Act respecting the Energy Efficiency of Electrical and Hydrocarbon-fuelled Appliances; Act respecting the Exportation of Electrical Power; Act respecting the Régie de l'Énergie; Act respecting the Régie du gaz naturel; Act respecting the Société québécoise d'exploration minière; Act respecting the Société québécoise d'initiatives pétrolières; Gas Distribution Act; Hydro-Québec Act; Mining Act; Mining Companies Act; Mining Duties Act; Municipal and Private Hydro Act; Petroleum Products Act
	Ontario	Energy Efficiency Act; Energy Act; Ministry of Energy Act; Ontario Energy Board Act; Power Corporation Act; Power Corporation Insurance Act; Rural Hydro-Electrical Distribution Act; Rural Power District Loans Act
	Manitoba	Energy Act; Energy Rate Stabilization Act; Gas Pipeline Act; Gas Storage and Allocation Act; Homeowners Tax and Insulation Assistance Act; Manitoba Natural Resources Development Act; Mineral Exploration Incentive Program Act and Regulations; Mines Act; Mines and Minerals Act; Mining and Metallurgy Compensation Act; Natural Gas Supply Act; Oil and Gas Act; Oil and Gas Production Tax Act and Regulations
	Saskatchewan	Crown Minerals Act; Department of Energy and Mines Act; Freehold Oil and Gas Production Tax Act and Regulations; Mineral Resources Act and Regulations; Oil and Gas Conservation Act and Regulations; Pipelines Act and Regulations; Potash Resources Act
	Alberta	Electric Utilities Act; Energy Resources Conservation Act; Gas Resources Preservation Act; Gas Utilities Act; Mines and Minerals Act and Regulation; Oil and Gas Conservation Act and Regulations; Oil Sands Conservation Act and Regulations; Petroleum Incentives Program Act and Regulations; Pipeline Act and Regulations; Public Utilities Board Act
	British Columbia	Coal Act and Regulations; Energy Council Act; Energy Efficiency Act; Fort Nelson Indian Reserve Mineral Revenue Sharing Act; Gas Utility Act; Geothermal Resources Act and Regulations; Hydro and Power Authority Act; Hydro and Power Authority Privatization Act; Hydro Powers Measure Act; Mineral Tax Act; Mineral Tenure Act and Regulations; Mines Act; Mining Right of Way Act; Natural Gas Price Act; Natural Resources Community Fund Act; Petroleum and Natural Gas Act; Pipeline Act; Vancouver Island Natural Gas Pipeline Act
	Yukon Territory	Energy Conservation Assistance Act; Gasoline Handling Act and Regulations; Lands Act and Regulations
	Northwest Territories	Natural Resources Conservation Trust Act; Gas Protection Act

Source:
Canadian Environmental Directory 1997/98, Seventh Edition, Copp Clark Professional, Toronto.

approval and/or federal financial assistance. Federal legislation of the forestry industry is limited to those lands it owns, including national parks, airports, military and First Nations lands.

Legislation on pollution

Pollution legislation targets different types of pollution from industry and other human activities, including solid waste, hazardous waste and noise (Table 7.1.5). Through CEPA's regulations and guidelines, the federal government has the authority to address pollution problems on land, on water and in the atmosphere (Text Box 7.1.4).

Generally, provincial and territorial governments regulate waste management activities within their borders. This includes the generation, transportation, recycling and disposal of waste. Because of the regional nature of solid waste, the provinces delegate much of the responsibility for its collection, removal and disposal to municipal governments.

Table 7.1.5
Federal, Provincial and Territorial Environmental Legislation on Pollution

Topic	Jurisdiction	Legislation
Hazardous waste	Federal	Feeds Act and Regulations; Fertilizers Act and Regulations; Pest Control Products Act; Pesticide Residue Compensation Act; Transportation of Dangerous Goods Act and Regulations; Food and Drugs Act; Hazardous Materials Information Review Act; Hazardous Materials Information Review Act Appeal Board Procedures Regulations; Hazardous Products Act; Radiation-Emitting Devices Act and Regulations; Non-Smokers' Health Act and Regulations; Atomic Energy Control Act; Canada Oil and Gas Operations Act; Nuclear Liability Act; Canada Shipping Act
	Newfoundland	Aquaculture Act and Regulations; Pesticides Control Act and Regulations; Radiation Health and Safety Act and Regulations; Waste Material Act
	Prince Edward Island	Pesticides Control Act and Regulations; Recreation Development Act; Fire Prevention Act; Dangerous Goods Act
	Nova Scotia	Aquaculture Act; Dangerous Goods Transportation Act and Regulations
	New Brunswick	Occupational Health and Safety Act; Pesticides Control Act; Injurious Insect and Pest Act; Aquaculture Act; Radiological Health Protection Act; Pipeline Act; Fire Prevention Act
	Quebec	Occupational Health and Safety Act; Explosives Act; Fire Prevention Act
	Ontario	Energy Act; Gasoline Handling Act; Highway Traffic Act; Pesticides Act; Waste Management Act, 1992; Occupational Health and Safety Act; Smoking in the Workplace Act
	Manitoba	Pesticides and Fertilizers Control Act; Gas Storage and Allocation Act; Contaminated Sites Remediation Act; Dangerous Goods Handling and Transportation Act; High-Level Radioactive Waste Act; Manitoba Hazardous Waste Management Corporation Act; Public Health Act; Workplace Safety and Health Act
	Saskatchewan	Pest Control Act; Pest Control Products Act; Pipelines Act; Dangerous Goods Transportation Act and Regulations; Radiation Health and Safety Act; Fire Prevention Act
	Alberta	Agricultural Pests Act; Environmental Protection and Enhancement Act; Special Waste Management Corporation Act; Transportation of Dangerous Goods Control Act and Regulations
	British Columbia	Petroleum and Natural Gas Act; Pipeline Act; Pesticide Control Act and Regulations; Waste Management Act; Motor Vehicle Act; Transport of Dangerous Goods Act
	Yukon Territory	Dangerous Goods Transportation Act and Regulations; Fire Prevention Act; Occupational Health and Safety Act and Regulations
	Northwest Territories	Fire Prevention Act; Transportation of Dangerous Goods Act and Regulations; Pesticides Act
Solid waste	Federal	Indian Act; Canada Shipping Act; Canadian Environmental Protection Act
	Newfoundland	Quarry Materials Act; Highway Traffic Act; Waste Material Disposal Act
	Prince Edward Island	Highway Traffic Act; Roads Act; Municipalities Act
	Nova Scotia	Village Service Act; Litter Abatement Act; Motor Vehicle Act; Towns Act; Public Highways Act; Recycling Act; Mineral Resources Act
	New Brunswick	Motor Vehicle Act; Agricultural Operations Practices Act; Highway Act; Beverage Containers Act
	Quebec	Mining Act
	Ontario	Farm Practices Protection Act; Aggregate Resources Act; Mining Act; Public Lands Act; Ontario Waste Management Corporation Act
	Manitoba	Waste Reduction and Prevention Act; Rivers and Streams Act; Highway Traffic Act; Mines Act; Mines and Minerals Act
	Saskatchewan	Pollution (by Livestock) Control Act; Highways and Transportation Act; Litter Control Act; Rural Municipalities; Highway Traffic Act
	Alberta	Environmental Protection and Enhancement Act
	British Columbia	Transport of Dangerous Goods Act; Waste Management Act; Mineral Tenure Act; Municipal Act; Hazardous Waste Management Corporation Act; Water Act; Park Act; Soil Conservation Act
	Yukon Territory	Environment Act
	Northwest Territories	Environmental Protection Act
Noise and vibration	Federal	Aeronautics Act and Regulations
	Newfoundland	Highway Traffic Act
	Prince Edward Island	Highway Traffic Act; Off-Highway Vehicle Act
	Nova Scotia	Motor Vehicle Act; Public Highways Act
	New Brunswick	Agricultural Operations Practices Act; All-Terrain Vehicle Act; Motor Vehicle Act
	Quebec	Environment Quality Act
	Ontario	Farm Practices Protection Act; Highway Traffic Act; Motorized Snow Vehicles Act; Off-Road Vehicles Act
	Manitoba	Highway Traffic Act
	Saskatchewan	Highway Traffic Act; All-Terrain Vehicles Act;
	Alberta	Energy Resources Conservation Act; Highway Traffic Act
	British Columbia	Motor Vehicle Act;
	Yukon Territory	Motor Vehicles Act; Noise Prevention Act
	Northwest Territories	Motor Vehicles Act

Source:
Canadian Environmental Directory 1997/98, Seventh Edition, Copp Clark Professional, Toronto.

Text Box 7.1.4

Regulations and Guidelines under the *Canadian Environmental Protection Act*

- Alberta Equivalency Order (SOR/94-752)
- Asbestos Mines and Mills Release Regulations (SOR/90-341)
- Benzene in Gasoline Regulations (SOR/97-493)
- Chlor-Alkali Mercury Release Regulations (SOR/90-130)
- Chlorobiphenyls Regulations (SOR/91-152)
- Chlorofluorocarbon Regulations, 1989 (SOR/90-127)
- Code of Practice for the Reduction of Chlorofluorocarbon Emissions from Refrigeration and Air Conditioning Systems
- Contaminated Fuel Regulations (SOR/91-486)
- Diesel Fuel Regulations (SOR/97-110)
- Domestic Substances List (SOR/94-311)
- Enforcement and Compliance Policy
- Environmental Code of Practice for Above-ground Storage Tank Systems Containing Petroleum Products
- Environmental Code of Practice for Elimination of Fluorocarbon Emissions from Refrigeration and Air Conditioning Systems
- Environmental Code of Practice for Underground Storage Tank Systems Containing Petroleum Products
- Environmental Code of Practice on Halons
- Export and Import of Hazardous Waste Regulations (SOR/92-637)
- Federal Above-ground Storage Tank Technical Guidelines
- Federal Mobile PCB Treatment and Destruction Regulations (SOR/90-5)
- Federal Underground Storage Tank Guidelines
- Fuels Information Regulations No.1 Technical (C.R.C., c. 407)
- Gasoline Regulations (SOR/90-247)
- Guidelines for Submission under Section 17 of the Canadian Environmental Protection Act
- List of Hazardous Waste Authorities (SOR/92-636) and List of Toxic Substances Authorities (SOR/94-162)
- Masked Name Regulations (SOR/94-261)
- Mirex Regulations, 1989 (SOR/90-126)
- National Emission Guidelines for Stationary Combustion Turbines
- New Substances Notification Regulations (SOR/94-260)
- Notice with Respect to Substances in the National Pollutant Release Inventory for 1997
- Ocean Dumping Regulations, 1988 (SOR/89-500)
- Ozone-depleting Substances Regulations (SOR/95-576)
- PCB Waste Export Regulations, 1996 (SOR/97-109)
- Phosphorous Concentration Regulations (SOR/89-501)
- Polybrominated Biphenyls Regulations, 1989 (SOR/90-129)
- Polychlorinated Terphenyls Regulations, 1989 (SOR/90-128)
- Prohibition of Certain Toxic Substances Regulations (SOR/96-237)
- Pulp and Paper Mill Defoamer and Wood Chip Regulations (SOR/92-268)
- Pulp and Paper Mill Effluent Chlorinated Dioxins and Furans Regulations (SOR/92-267)
- Registration of Storage Tank Systems for Petroleum Products and Allied Petroleum Products on Federal Lands (SOR/97-10)
- Reporting for the Domestic Substances List
- Secondary Lead Smelter Release Regulations (SOR/91-155)
- Storage of PCB Material Regulations (SOR/92-507)
- Toxic Substances Export Notification Regulations (SOR/92-634)
- Toxic Substances Management Policy
- Toxic Substances Management Policy: Persistence and Bioaccumulation Criteria
- Toxic Substances Management Policy: Report on Public Consultations
- Vinyl Chloride Release Regulations, 1992 (SOR/92-631)

Source:
Templegate Information Services, 1998.

Federal legislation is largely restricted to federal facilities and lands and to the interprovincial and international movement of hazardous waste. Noise pollution is also primarily the responsibility of the provincial and municipal governments. Noise associated with interprovincial transportation systems such as airports, train stations and navigable waterways, however, is regulated federally.

Environmental impact assessment legislation

This proactive type of legislation (Table 7.1.6) requires environmentally sensitive projects to go through an environmental assessment (EA) process, in order to encourage the maintenance of both a strong economy and a healthy environment. Possible EA outcomes for a project include approving it as planned, pursuing it after measures to address any environmental concerns are provided, and stopping it from proceeding altogether.

The federal and provincial and territorial governments have their own EA legislation to be applied to projects under their jurisdiction. Some projects may fall under both levels of government and may require two separate EAs.

The Canadian Environmental Assessment Agency administers and promotes environmental assessment policies and practices under federal EA legislation. Projects that fall under the federal EA include:

- those involving federal funding;
- those where federal land is involved or where the federal government is the proponent;
- those where there is potential for transboundary environmental impacts; and
- those falling under the law list.

Table 7.1.6
Environmental Assessment Legislation by Jurisdiction

Jurisdiction	Legislation
Federal	Canadian Environmental Assessment Act
Newfoundland	Environmental Assessment Act and Regulations
Prince Edward Island	Environmental Protection Act
Nova Scotia	Environment Act
New Brunswick	Clean Environment Act
Quebec	Environment Quality Act
Ontario	Environmental Assessment Act
Manitoba	Environment Act
Saskatchewan	Environmental Assessment Act
Alberta	Environmental Protection and Enhancement Act
British Columbia	Environmental Assessment Act
Yukon Territory	Canadian Environmental Assessment Act
Northwest Territories	Canadian Environmental Assessment Act

Source:
Canadian Environmental Directory 1997/98, Seventh Edition, Copp Clark Professional, Toronto.

Table 7.1.7
Federal Reasons for Project Environmental Assessments, 1994-95 to 1996-97

Reason	1994-95	1995-96	1996-97
	number of projects		
Federal funding	473	2 068	1 202
Proponent	130	1 048	1 226
Land	91	615	507
Transboundary/interprovincial	..	..	..
Transboundary effects on federal lands	..	1	7
Law list	344	1 819	1 540
Total	**1 038**	**5 551**	**4 482**

Source:
Canadian Environmental Assessment Agency.

The law list represents federal licenses, permits, certificates and any other regulatory authorization that could trigger the environmental assessment process for a project in question. Federal government funding and the law list are the two main factors triggering the federal EA process (Table 7.1.7).

7.1.3 Enforcing environmental legislation

Enforcement and the application of penalties discourage activities that have a negative impact on the environment. These enforcement activities are applied at the federal, provincial and territorial levels of government. Resulting enforcement statistics are available for key environmental legislation; reporting and availability of statistics on enforcement activities vary across the provinces and territories.

Canadian Environmental Protection Act (CEPA)

Enforcement activities under CEPA range from investigations to prosecutions and convictions under the Act. Between 1991–92 and 1995–96, enforcement activities declined by 35%, and much of the decline is attributed to a reduction in the number of inspections conducted (Table 7.1.8).

Table 7.1.8
CEPA Enforcement Activities, 1991-92 to 1995-96

Enforcement activity	1991-92	1992-93	1993-94	1994-95	1995-96
Inspections	1 574	1 233	1 548	1 362	963
Investigations	120	93	55	64	94
Warnings	82	105	120	127	87
Directions	6	4	1	-	-
Prosecutions	16	22	3	8	15
Convictions	2	17	10	9	8
Total	**1 800**	**1 474**	**1 737**	**1 570**	**1 167**

Source:
CEPA Annual Reports, April to March.

Table 7.1.9
National Enforcement Activities, July 1, 1988 to June 30, 1996

CEPA contraventions	Inspections	Investigations	Warnings	Directions	Prosecutions	Convictions
			number			
PCB waste storage	3 047	105	495	7	6	3
PCB regulations	3 127	205	400	10	7	5
PCB waste export	55	1	7	-	-	
PCB destruction	151	6	1	-	-	
Secondary lead smelter release	310	2	15	3	-	-
Vinyl chloride release	47	6	1	2	1	1
Asbestos mines and mills release	182	-	5	1	-	-
Mercury, chlor-alkali release	125	4	3	-	-	-
Chlorofluorocarbons release	226	2	1	-	-	-
Domestic Substance List	5	-	-	-	-	-
Gasoline regulations	3 713	32	26	-	7	7
Contaminated fuel	863	2	38	-	-	-
Fuels information regulation	10	5	1	-	-	-
Ozone substances	225	65	21	-	14	13
Ozone-depleting products	1 019	123	97	2	20	16
Ocean dumping	825	86	64	4	18	14
Export-import hazardous wastes	623	30	23	-	10	2
Phosphorous concentration	395	6	5	-	1	1
Dioxins and furans	146	4	19	-	-	-
Defoamer and wood chips	118	-	2	-	-	-
Toxic Substances Export Notification	5	-	-	-	-	-
Others	6	1	-	-	-	-
Total	**15 223**	**685**	**1 224**	**29**	**84**	**62**

Source:
Canadian Environmental Directory 1997/98, Seventh Edition, Copp Clark Professional, Toronto.

Although inspections make up the majority of enforcement activities, relatively few have led to prosecutions and convictions. Overall, the PCB waste storage and regulations and the gasoline and ozone-depleting product provisions of CEPA have provoked the most enforcement activity. Ozone-depleting products and ocean dumping have had the greatest incidence of prosecutions and convictions since 1988 (Table 7.1.9).

CEPA is also responsible for producing the National Pollutant Release Inventory (NPRI), the only legislated inventory of pollutant releases in Canada. Any individual who owns or operates a facility that manufactures, processes or uses any NPRI substance in quantities above specified thresholds must report it under the NPRI (see section 7.4–**Environmental practices** for more detail).

Fisheries Act

In terms of legislation protecting specific components of the environment, the *Fisheries Act*, administered jointly by the Department of Fisheries and Oceans and Environment Canada, is the primary federal legislation for coastal waters and fisheries. Its purpose is to protect fish stocks and habitats. The *Fisheries Act* addresses two main types of offence: physical damage to and alteration of fish habitat; and the release of substances that may negatively affect fish and their habitat. The total number of convictions resulting from this act remained relatively constant by province from 1994–95 to 1996–97, with the majority of convictions occurring in British Columbia (Table 7.1.10).

Canadian Environmental Assessment Act (CEAA)

In Canada, all provinces and territories have projects that require federal environmental impact assessments. Canada is also involved in foreign projects that undergo environmental impact assessments under the CEAA. This act covers four types of environmental assessments: screening, comprehensive study, mediation and panel review. All four are related and have a logical sequence; each represents a specific stage in the assessment process.

Not every project is subject to all levels of assessment. In fact, few assessments go beyond screening (Table 7.1.11).

Table 7.1.10
Convictions under the *Fisheries Act*, 1994-95 to 1996-97

Province/Territory	1994-95	1995-96	1996-97
Newfoundland	-	1	2
Prince Edward Island	-	2	2
Nova Scotia	1	3	6
New Brunswick	1	7	2
Quebec	-	1	-
Ontario	9	10	15
Manitoba	1	-	-
Saskatchewan	-	-	-
Alberta	1	-	-
British Columbia	62	35	49
Yukon Territory	-	2	
Northwest Territories	1	-	-
Total	**76**	**61**	**76**

Source:
Department of Fisheries and Oceans.

Table 7.1.11
Federal Environmental Assessment, 1994-95 to 1997-98

Assessment type	1994-95	1995-96	1996-97	1997-98
Screening	1 038	5 551	4 482	2 490
Comprehensive study	1	9	11	3
Mediation/Joint panel	1	2	4	-

Source:
Canadian Environmental Assessment Agency.

Screening assessments outline the anticipated effects of the proposed project. However, more environmentally sensitive projects and larger-scale projects require a comprehensive study. Those projects requiring further assessment go to mediation or to a panel review where a decision will be made on whether the project can proceed.

The total number of projects with a screening assessment more than quadrupled between 1994–95 and 1995–96, but declined in the following year (Table 7.1.12). The provinces of British Columbia, Saskatchewan, Quebec and Ontario have relatively large numbers of projects being assessed through the CEAA.

Aside from legislation, Canadian governments may use economic instruments such as environmental taxes (e.g., tire taxes) or deposit and return programs as mandatory measures to promote sustainable resource use (see subsections 7.4.1–**Mandatory environmental actions** and 7.4.4–**Reduction, reuse and recycling**).

7.1.4 Non-regulatory initiatives

In recent years, environmental legislation has given way somewhat to the rise of non-regulatory alternatives. For instance, governments, industry and individuals voluntarily participate in a variety of initiatives that address different environmental issues. There is usually an incentive to prompt a proponent's voluntary participation. Text Box 7.1.5 contains several examples of voluntary initiatives in Canada, some of which have a global context.

Table 7.1.12
Federal Environmental Screening Assessments, 1994-95 to 1996-97

Province/Territory	1994-95	1995-96	1996-97
Newfoundland	48	176	293
Prince Edward Island	13	165	156
Nova Scotia	90	349	296
New Brunswick	77	292	212
Quebec	170	1 024	608
Ontario	93	620	524
Manitoba	25	185	256
Saskatchewan	181	1 042	696
Alberta	127	497	383
British Columbia	60	622	723
Yukon Territory	63	181	2
Northwest Territories	83	361	280
Outside Canada	8	37	53
Total	**1 038**	**5 551**	**4 482**

Source:
Canadian Environmental Assessment Agency.

Table 7.1.13
Examples of International Co-operation on Environmental Issues

Issue	Convention/Treaty/Agreement
Air and atmosphere	Convention on Long-Range Transboundary Air Pollution
	Vienna Convention for the Protection of the Ozone Layer
	Montreal Protocol on Substances that Deplete the Ozone Layer
Biodiversity	Convention on Biological Diversity
Climate change	United Nations Framework Convention on Climate Change
	Kyoto Protocol
Ecosystems	Antarctic Treaty
	Convention on Wetlands of International Importance
Flora and fauna	Convention on International Trade in Endangered Species (CITES)
	Convention for the Conservation of Salmon in the North Atlantic Ocean
	International Plant Protection Convention
Hazardous substances	Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal
	Agreement between Canada and the United States Concerning the Transboundary Movement of Hazardous Waste
Oceans	Convention on the Prevention of Marine Pollution by Dumping Wastes and Other Matter
	International Convention on Oil Pollution Preparedness, Response and Co-operation
Rivers and lakes	1909 Boundary Waters Treaty
	Great Lakes Water Quality Agreement
Soils	United Nations Convention to Combat Desertification
Environmental co-operation	North American Agreement on Environmental Co-operation

Sources:
Environment Canada, "International Agreements," <http://www.naaec.gc.ca/english/resource/Agreements.html>, (accessed July 15, 1999).
Commissioner of the Environment and Sustainable Development, Database of Canada's International Environmental Commitments, <http://www.oag-bvg.gc.ca/domino/env_commitments.nsf/homepage>, (accessed July 15, 1999).

7.1.5 International initiatives

Environmental issues are often international in nature and so require international solutions. Canada participates in a variety of international agreements, treaties and conventions (Table 7.1.13). The information presented and the agreements reached between nations at international forums influence domestic legislation and policy.[1]

1. Environment Canada, Green Lane, <http://ec.gc.ca>.

Text Box 7.1.5

Examples of Voluntary Initiatives in Canada

- **Voluntary Challenge and Registry (VCR):** This voluntary initiative, started in 1994, addresses the issue of climate change by encouraging private and public sector organizations to reduce their greenhouse gas emissions. Organizations from all sectors of the economy currently belong to the VCR program, including federal and provincial governments. For more details on the VCR, see section 7.4–**Environmental practices** and <http://www.vcr-mvr.ca>.
- **Accelerated Reduction/Elimination of Toxics Program (ARET):** Launched in 1994, this program targets the reduction and elimination of 117 toxic substances through voluntary commitments. Participants submit action plans detailing reduction goals and strategies. For more details on ARET, see section 7.4–**Environmental practices**.
- **Automotive Manufacturing Pollution Prevention Project:** Signed in 1992, this project is a memorandum of understanding among Environment Canada, the Ontario Ministry of Environment and Energy and the Motor Vehicles Manufacturing Association (MVMA). Its goal is to reduce, eliminate and prevent the use of 29 substances from automotive operations in the Great Lakes Basin. MVMA members include, among others, Ford, Chrysler and General Motors.
- **Canadian Chemical Producers' Association Benzene Agreement:** The agreement is a memorandum of understanding between Environment Canada and the Canadian Chemical Producers' Association (CCPA). Its goal was a 68% reduction in benzene emissions by 1999, compared to the 1994 base year.[1]
- **Responsible Care:** This international initiative of the chemical industry commits companies to improving their health, safety and environmental performance. Companies also have open dialogue with the public and other interested parties. Forty-one national chemical associations have become part of Responsible Care, which represents 88% of the world's chemical production. The Canadian Chemical Producers' Association (CCPA) started this initiative in the mid-1980s. For more details on this program, see section 7.4–**Environmental practices**.
- **ISO 14000:** ISO 14000 is an international voluntary initiative developed under the International Standards Organization (ISO), a non-governmental organization. The ISO 14000 series develops standards that address environmental management systems, environmental auditing, environmental labelling, environmental performance evaluation and life cycle assessment. For more details on this program, see section 7.4–**Environmental practices** and <http://web.ansi.org/public/iso14000>.
- **ÉcoGeste:** This Quebec program for registration of voluntary measures on climate change was put in place by the *ministère de l'Environnement et de la Faune* and the *ministère des Ressources naturelles*. These measures are taken by all private and public organizations (governments, businesses and groups of individuals). For more details, see section 7.4–**Environmental practices** and <http://www.mef.gouv.qc.ca/fr/environn/dev_dur/ecogeste.htm>.
- **Voluntary Actions on Climate Change:** For an inventory of other voluntary initiatives related to GHG emissions,[2] see section 7.4–**Environmental practices**.

1. Templegate Information Services.
2. Climate Change Directorate, 1998, *Enhanced Voluntary Action Issues Table*, Foundation Paper, Ottawa.

7.2 Environmental protection expenditures

Governments, businesses and households all contribute in their own ways to minimize the harmful effects their production and consumption activities have on environmental quality and resource availability. One method of assessing the effectiveness of these activities is to measure expenditures made on environmental protection[1] (Text Box 7.2.1).

> Text Box 7.2.1
> **Environmental Protection Expenditures**
>
> Environmental protection expenditures are defined as all capital (or investment) expenditures and operating (or current) expenditures that are undertaken with the intention of preventing, reducing and remedying pollution or other sources of environmental degradation, or preserving the environment.
>
> The difficulty is to measure multiple-purpose expenditures, that is, expenditures that are made in order to reduce costs but that, at the same time, reduce energy consumption or waste generation. This is a particular problem with business expenditures. For that reason, the definition criterion has been expanded to include any expenditure that ensures or anticipates compliance to environmental regulation or official voluntary agreement. Environmental protection expenditures are classified as follows:
>
> - **Pollution abatement and control (PAC) expenditures**: expenditures for solid waste management; for wastewater management; for environmental monitoring (e.g., air quality); and for equipment and construction used to prevent or reduce pollution;
> - **Other environmental protection expenditures**: expenditures for site reclamation and decommissioning; for environmental assessments and audits; and for protection and restoration of wildlife and habitat.
>
> Expenditures on environmental research and development are covered by the definition; however, they are excluded from the data on business expenditures shown in this section (section 7.4–**Environmental practices**).

1. Household expenditures do not appear in this section because of lack of data. Section 7.5–**Public participation** lists various activities that can be used to identify individual contributions aimed at reducing the impact of human activities on the environment.

7.2.1 Governments

Government expenditures on the environment provide some idea of the scope and nature of government environmental protection activities.[2] These expenditures[3] (Text Box 7.2.2) are also indicators of government production of environmental goods and services.

Government expenditures on pollution abatement and control (PAC)

In 1996, government PAC expenditures totalled just over $5.4 billion[4] (Table 7.2.1) or 0.7% of Canada's Gross Domestic Product (GDP). Government PAC expenditures increased from $0.3 billion in 1970 to just under $3.4 billion in 1988. In the 1990s, most of the growth in PAC expenditures has been due to sewage collection and disposal projects. As a result, local government expenditures on PAC generally increased until 1995. Expenditures on PAC by the federal and provincial governments increased until 1994 (Table 7.2.2).

PAC expenditures as a proportion of total government expenditures are relatively small. The share of government expenditures allocated to PAC generally fell from the early 1970s until the late 1980s. Since then, however, that share has remained between 2.7% and 2.9% (Figure 7.2.1). Furthermore, from 1988 to 1997, local governments dedicated an average of 15.8% of their gross fixed capital formation[5] to PAC investment and around 17.3% in 1997 (Figure 7.2.2). In comparison, business invested 1.4% of their gross fixed capital formation on PAC in 1996.

Government expenditures on PAC have generally been increasing at a greater pace than total government expenditures. For example, from 1970 to 1996, total government expenditures increased at an average rate of 8.8% per year, while government expenditures on PAC grew at an average rate of 11.7% per year.

Almost half of government expenditures on PAC were directed toward sewage collection and disposal in 1995 and 1996. Waste collection and disposal accounted for a quarter of government PAC expenditures, while expenditures on other pollution control and environmental services accounted for slightly more (Figure 7.2.3 and Table 7.2.1).

2. Section 7.1–**Environmental legislation and non-regulatory initiatives** provides an overview of government legislation on the environment.
3. Government expenditures on wildlife and habitat protection are not included here because estimates are not available.
4. In comparison, total business sector expenditures on PAC were estimated at nearly $4.9 billion in 1996 (subsection 7.2.2).
5. Government gross fixed capital formation refers to expenditures by the government sector on new durable assets such as sewage systems.

Text Box 7.2.2

Government Expenditures on Pollution Abatement and Control (PAC)

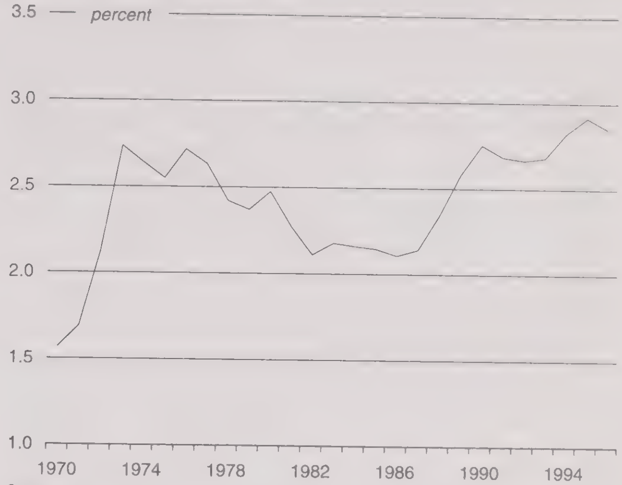
Government current and capital expenditures on PAC include the following categories:

- **Sewage collection and disposal expenditures:** expenditures for sewerage management, including construction, equipment and maintenance of sewage removal and treatment facilities; for inspection and cleaning of sewers; and for subsidies related to assistance and research in this area;
- **Waste collection and disposal expenditures:** expenditures for waste management, including construction, equipment and maintenance of garbage and waste collection and disposal facilities (such as landfill sites, incineration and recycling) and landfill site cleanup; for managing waste collection and disposal programs; and for subsidies related to assistance and research in this area;
- **Other pollution control expenditures:** expenditures for construction, equipment and maintenance of pollution abatement facilities other than waste and sewage; for managing programs to prevent or to reduce air, water, soil or groundwater pollution; and for subsidies related to assistance and research in these areas; and
- **Other environmental services expenditures (not elsewhere classified):** expenditures for services such as general administration of the ministry of environment, education, environmental assessments, and contributions to environmental agencies. These expenditures are not just for PAC since some of the activities may involve assessments of projects for their overall environmental impact and clean-up activities that should be treated separately. However, because of the impossibility of breaking down this category further, it was decided that the 'other environmental services' category should be included under PAC.

Expenditures on water purification and distribution are excluded because they are considered to relate to human health rather than to environmental protection. However, it is possible that in certain provinces, expenditures on sewerage management are included under this category. Consequently, Table 7.2.2 shows expenditures on water purification and distribution in addition to PAC expenditures.

Figure 7.2.1

Pollution Abatement and Control as a Share of Total Government Expenditures, 1970-1996



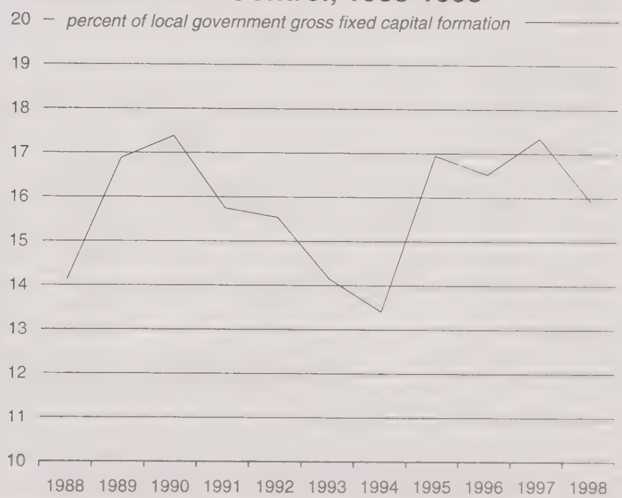
Sources:
Statistics Canada, Environment Accounts and Statistics Division, Public Institutions Division, and CANSIM, matrix 6521 and series d14822 and 14823.

PAC expenditures by level of government

The nature of PAC activities varies according to the level of government. Local governments have the responsibility of providing infrastructure for waste and sewage disposal and treatment (Table 7.2.2). Meanwhile, federal, provincial and territorial governments are involved in legislation on environmental issues, such as cleaning up sites, developing and maintaining programs to prevent or reduce pollution, and monitoring air, water and soil quality.

Figure 7.2.2

Local Government Investment on Pollution Abatement and Control, 1988-1998



Note:
1996 and 1997 figures are estimates.

Sources:
Statistics Canada, Environment Accounts and Statistics Division, Public Institutions Division, and CANSIM, matrix 735 and series d151640.

Table 7.2.1
Government Pollution Abatement and Control Expenditures, 1988-1996

Year[1]	Total PAC expenditures	Total government expenditures	Sewage collection and disposal as a share of total PAC expenditures	Waste collection and disposal as a share of total PAC expenditures	'Other PAC'[2] as a share of total PAC expenditures	Total PAC as a share of total government expenditures
	million dollars		percent			
1988	3 376	144 107	41.9	26.3	31.8	2.3
1989	4 044	156 712	42.9	25.7	31.4	2.6
1990	4 715	171 223	42.4	25.9	31.7	2.8
1991	4 886	181 974	40.0	27.1	32.9	2.7
1992	5 015	188 098	40.9	28.5	30.6	2.7
1993	5 101	190 189	42.9	26.4	30.8	2.7
1994	5 433	192 371	42.3	29.0	28.7	2.8
1995	5 652	192 983	48.5	24.2	27.3	2.9
1996	5 424	191 291	48.4	24.7	26.9	2.8

Notes:
Figures may not add up to 100% due to rounding.
Estimates represent consolidated government expenditures. Intergovernmental transfers are netted out.
Differences between these figures and estimates published in *Human Activity and the Environment 1994* or any other publication are due to historical revisions and improvements in data quality.
1. Fiscal year ending nearest to March 31.
2. The 'Other PAC' expenditure category includes general pollution control activities (e.g., clean-up) as well as other environmental services such as the administration of environment departments and environmental assessments.

Sources:
Statistics Canada, Environment Accounts and Statistics Division, Public Institutions Division, and CANSIM, matrix 6521 and series d14822 and d14823.

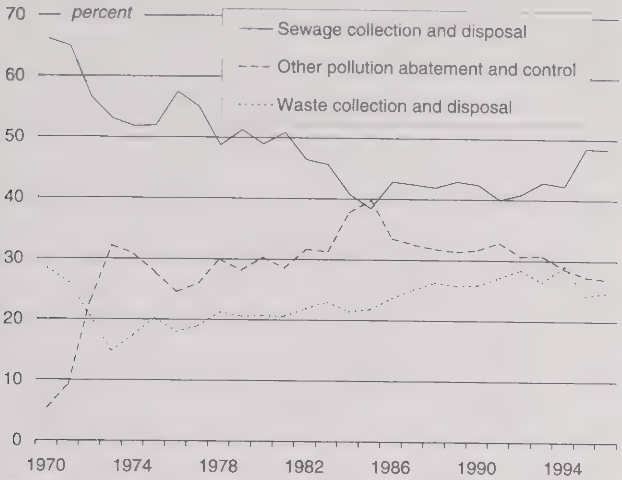
Table 7.2.2
Government Expenditures on Pollution Abatement and Control and Water Purification and Supply, 1988-1998

Level of government/activity	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
	million dollars										
All levels											
Sewage collection and disposal	1 416.1	1 736.3	2 001.1	1 953.3	2 051.3	2 186.1	2 297.4	2 742.2	2 622.5	..	..
Waste collection and disposal	886.7	1 039.8	1 220.3	1 324.7	1 427.2	1 346.2	1 578.1	1 366.4	1 340.5	..	..
Other pollution control activities	268.7	357.6	397.6	318.9	263.8	239.6	240.3	204.2	186.7	..	..
Other environmental services	804.4	910.4	1 096.3	1 289.0	1 272.6	1 329.2	1 317.1	1 338.7	1 274.0	..	..
Total PAC	**3 375.9**	**4 044.0**	**4 715.3**	**4 885.9**	**5 014.8**	**5 101.1**	**5 432.9**	**5 651.5**	**5 423.7**	**..**	**..**
Water purification and supply	2 099.8	2 247.7	2 470.5	2 377.3	2 426.0	2 747.5	2 965.6	3 014.0	3 032.6	..	..
PAC and water	**5 475.7**	**6 291.7**	**7 185.8**	**7 263.2**	**7 440.8**	**7 848.6**	**8 398.4**	**8 665.5**	**8 456.3**	**..**	**..**
Federal[1]											
Sewage collection and disposal	-	-	-	-	-	229.4	320.7	313.7	300.7	371.5	336.6
Waste collection and disposal	-	-	-	-	-	-	-	-	-	-	-
Other pollution control activities	70.3	112.6	117.9	20.2	4.3	11.2	14.7	13.9	5.7	4.7	4.6
Other environmental services	505.7	545.4	620.2	720.9	747.0	728.7	745.3	703.2	635.6	761.8	823.9
Total PAC	**576.1**	**657.9**	**738.1**	**741.1**	**751.4**	**969.4**	**1 080.8**	**1 030.7**	**942.0**	**1 138.0**	**1 165.1**
Water purification and supply	23.8	16.0	7.1	7.8	9.6	235.1	344.7	360.0	328.9	392.0	351.9
PAC and water	**599.9**	**673.9**	**745.2**	**748.9**	**761.0**	**1 204.5**	**1 425.5**	**1 390.8**	**1 270.9**	**1 529.9**	**1 517.0**
Provincial/Territorial[2]											
Sewage collection and disposal	75.7	72.4	75.3	100.9	97.8	90.6	132.8	256.3	176.3	..	..
Waste collection and disposal	81.0	120.5	132.4	164.1	176.7	121.5	295.8	71.3	27.2	..	..
Other pollution control activities	243.7	305.0	327.3	375.8	328.2	309.9	235.8	202.2	190.0	..	..
Other environmental services	253.9	312.3	443.4	535.0	467.0	516.7	531.3	564.0	530.7	..	..
Total PAC	**654.3**	**810.3**	**978.4**	**1 175.7**	**1 069.7**	**1 038.7**	**1 195.5**	**1 093.8**	**924.2**	**..**	**..**
Water purification and supply	933.6	1 071.9	1 130.6	1 012.5	991.5	872.3	948.6	985.8	995.1	..	..
PAC and water	**1 587.9**	**1 882.2**	**2 109.0**	**2 188.3**	**2 061.3**	**1 911.0**	**2 144.1**	**2 079.6**	**1 919.3**	**..**	**..**
Local[3]											
Sewage collection and disposal	1 413.6	1 734.8	2 002.0	1 954.3	2 055.8	1 950.5	2 040.7	2 419.7	2 326.7	2 359.5	2 120.8
Waste collection and disposal	817.1	935.8	1 125.9	1 228.2	1 297.4	1 253.4	1 293.1	1 310.9	1 332.1	1 425.7	1 526.7
Other environmental services[4]	75.2	82.6	82.3	80.9	102.6	126.8	144.2	133.0	129.1	187.7	278.6
Total PAC	**2 305.9**	**2 753.2**	**3 210.2**	**3 263.4**	**3 455.7**	**3 330.7**	**3 478.0**	**3 863.6**	**3 787.9**	**3 972.8**	**3 926.1**
Water purification and supply	1 758.2	1 861.0	2 078.2	2 039.6	2 105.0	2 296.8	2 479.4	2 555.7	2 528.0	2 411.2	2 478.8
PAC and water	**4 064.1**	**4 614.2**	**5 288.5**	**5 303.0**	**5 560.8**	**5 627.5**	**5 957.4**	**6 419.3**	**6 315.9**	**6 384.1**	**6 404.9**

Notes:
Figures may not add up to totals due to rounding.
Fiscal year ending nearest to March 31, except for local government expenditures (year end closest to December).
Differences between these figures and estimates published in *Human Activity and the Environment 1994* or any other publication are due to historical revisions and improvements in data quality.
1. Federal government: 1998 numbers are estimates.
2. Estimates of provincial/territorial government expenditures by type of PAC activity are of lower quality than estimates for other governments. Therefore, estimates of provincial/territorial government expenditures by PAC activities have to be used with caution.
3. Local governments: 1996, 1997 and 1998 numbers are estimates.
4. Also includes other PAC activities such as clean-up and air pollution control.

Sources:
Statistics Canada, Environment Accounts and Statistics Division, and Public Institutions Division.

Figure 7.2.3
Government Expenditures on Pollution Abatement and Control by Activity, 1970-1996



Sources:
Statistics Canada, Environment Accounts and Statistics Division, and Public Institutions Division.

Despite initial declines throughout the 1970s, local governments have accounted for 60% to 70% of total government PAC expenditures since the 1980s (Figure 7.2.4). During the 1970s, around three-quarters of local government PAC expenditures were dedicated to sewage collection and disposal; the remaining expenditures were allocated almost completely to garbage and waste collection and disposal, including recycling. However, through the 1980s and 1990s, waste disposal took a larger share of the local government budget, reaching more than a third in 1997—but at the expense of sewage collection and disposal, whose share fell below 60% (Table 7.2.2).

Since the early 1980s, the federal, provincial and territorial governments have shared, almost equally, the remaining PAC expenditures. Approximately two-thirds of PAC expenditures at the federal level and more than half at the provincial and territorial level were dedicated to other environmental services in 1996 (Table 7.2.2).

The waste management industry: local government sector

The waste management industry provides a number of environmental services to Canadians. These include the collection and transportation of waste and of materials destined for recycling or reuse, the operation of transfer stations, and the treatment and disposal of hazardous waste. The waste management industry is part of the larger environment industry (see section 7.3–**The environment industry**). The importance of waste management in local government budgets across Canada demonstrates the significant role that these governments play in this industry, as both operators of waste management services and users of these services.

Of the various waste management activities undertaken by local governments, collection and transportation accounted for the largest share of current expenditures and the second-largest share of capital expenditures in 1996[1] (Table 7.2.3). The decline in current expenditures on disposal and recycling facilities observed between 1994 and 1996 may be partly due to governments cutting back their operating costs by consolidating facilities and improving efficiency.

1. Expenditures on waste management will differ from those found in Table 7.2.2 because of differences in data sources and methodology. These figures cover the following: surveyed municipalities with a population of 4 000 and greater; municipalities with waste disposal sites situated within their borders; provincial direct expenditures on waste management; and waste management boards and commissions.

Table 7.2.3
Local Government Current and Capital Expenditures on Waste Management by Activity,[1] 1994 and 1996

Activity	Current expenditures				Capital expenditures			
	1994	1996[2]	1994	1996[2]	1994	1996[2]	1994	1996[2]
	million dollars		percent		million dollars		percent	
Collection and transportation	415.4	500.6	35.9	45.4	5.5	24.0	5.4	21.4
Disposal facilities	455.2	325.3	39.8	29.5	76.4	57.6	76.2	51.3
Recycling facilities	185.8	80.2	16.7	7.3	12.8	16.9	12.7	15.1
Organics processing facilities[3]	..	13.4	..	1.1	..	2.1	..	1.9
Tipping fees[3]	..	102.5	..	9.3	...	...	...	...
Other activity[3]	91.9	81.9	7.7	7.4	5.7	11.6	5.7	10.4
Total	**1 148.2**	**1 103.9**	**100.0**	**100.0**	**100.3**	**112.1**	**100.0**	**100.0**

Notes:
Figures may not add up to totals due to rounding.
1. Expenditures on waste management will differ from those found under 'Waste collection and disposal' in Table 7.2.2 because of differences in data sources and methods. These figures cover the following: surveyed municipalities with a population of 5 000 and greater in 1994 and 4 000 and greater in 1996; municipalities with waste disposal sites situated within their borders; certain provincial direct expenditures on waste management; and waste management boards and commissions.
2. 1996 data are preliminary figures.
3. In 1994, 'Organics processing facilities' was included in 'Recycling facilities' or 'Other activity' while 'Tipping fees' was included in 'Other activity.'
Sources:
Statistics Canada, 1998, *Waste Management Industry Survey: Government Sector, 1994*, Catalogue No. 16F0002XIE, Ottawa, July.
Statistics Canada, 1999, *Waste Management Industry Survey: Business and Government Sectors, 1996*, Catalogue No. 16F0023XIE, Ottawa, October.
Statistics Canada, Public Institutions Division.

Table 7.2.4
Employment in Waste Management Industry: Local Government Sector, 1994 and 1996

Province/Territory	Total employment[1] 1994	Total employment[1] 1996	Change 1994-1996
	persons		percent
Newfoundland	75	164	119
Prince Edward Island	x	x	x
Nova Scotia	180	290	61
New Brunswick	140	128	-9
Quebec[2]	1 482	1 757	19
Ontario	2 698	2 960	10
Manitoba	258	549	113
Saskatchewan	152	310	104
Alberta	747	953	28
British Columbia	950	767	-19
Yukon Territory	x	x	x
Northwest Territories	x	x	x
Canada	**6 720**	**7 924**	**18**

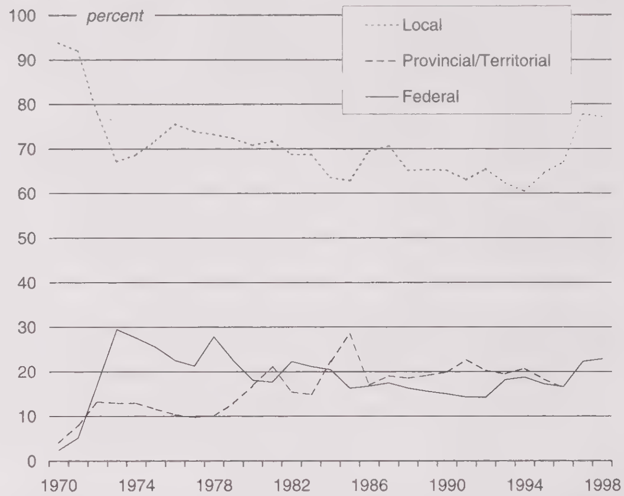
Notes:
1. Includes full-time and part-time employees working in the waste management activities of surveyed municipalities with a population of 5 000 and greater in 1994 and 4 000 and greater in 1996. No estimate has been made for non-surveyed municipalities.
2. Governments in Quebec were not surveyed on waste management-related employment. Estimates come from other sources.

Sources:
Statistics Canada, 1998, *Waste Management Industry Survey: Government Sector, 1994*, Catalogue No. 16F0002XIE, Ottawa, July.
Statistics Canada, 1999, *Waste Management Industry Survey: Business and Government Sectors, 1996*, Catalogue No. 16F0023XIE, Ottawa, October.
Statistics Canada, Public Institutions Division.

The number of full-time and part-time government employees in the waste management industry increased by 18% between 1994 and 1996, to just over 7 900 (Table 7.2.4). Most provinces, with the exception of British Columbia and New Brunswick, experienced an increase.

Interestingly, the growth in the number of government sector employees engaged in waste management activities took place over a period of government downsizing. Over the last several years, there has also been a trend by government to offload services to the private sector. While employment in government waste management grew, governments also increased the use of contractors to provide these services, particularly in the areas of collection, transportation and recycling (Table 7.2.5).

Figure 7.2.4
Government Expenditures on Pollution Abatement and Control by Level of Government, 1970-1998



Sources:
Statistics Canada, Environment Accounts and Statistics Division, and Public Institutions Division.

7.2.2 Businesses

The business sector is involved in a variety of practices aimed directly or indirectly at protecting the environment from the effects of its production activity. These activities have generally been brought about by environmental regulations and, more recently, by voluntary agreements and conventions (see section 7.1–**Environmental legislation and non-regulatory initiatives**). The necessity of complying with environmental regulations or conventions often generates a specific cost for businesses, unless a company adopts a new cost-saving production process.[1]

1. Sound business practices, such as the use of energy-saving devices, decrease production costs while generating environmental benefits.

Table 7.2.5
Local Government Current Expenditures on Waste Management[1] by Service Provider and Activity, 1994 and 1996

Activity	1994 In-house employees	1994 Contractors	1996 In-house employees	1996 Contractors	1996 Other governments[2]
	percent			percent	
Collection and transportation	45	55	39	61	-
Disposal facilities	59	41	48	51	1
Recycling facilities	38	62	37	62	1
Organics processing facilities[3]	..	..	47	53	-
Tipping fees[3]	..	..	18	51	32
Other activity[3]	50	50	73	26	1
Total	**50**	**50**	**42**	**54**	**4**

Notes:
These figures cover surveyed municipalities with a population of 5 000 and greater in 1994 and 4 000 and greater in 1996.
1. This distribution by service provider includes estimates for surveyed municipalities, as well as estimates for non-surveyed municipalities.
2. The 1996 Waste Management Industry Survey: Government Sector included 'Other governments.' This category was covered under 'Contractors' in the 1994 data.
3. 'Tipping fees' and 'Organics processing facilities' were included in 'Other activity' in 1994.

Sources:
Statistics Canada, 1998, *Waste Management Industry Survey: Government Sector, 1994*, Catalogue No. 16F0002XIE, Ottawa, July.
Statistics Canada, 1999, *Waste Management Industry Survey: Business and Government Sectors, 1996*, Catalogue No. 16F0023XIE, Ottawa, October.
Statistics Canada, Public Institutions Division.

Text Box 7.2.3
Definition of Business Environmental Protection Expenditures

Environmental protection expenditures are defined as all operating and capital and repair expenditures (investment expenditures) incurred in order to comply with or to anticipate environmental regulations or conventions that apply to Canada. Environmental conventions include any formal multiparty commitment to meet specific targets relating to habitat protection and waste and pollution abatement, such as the Canada–U.S. Air Quality Agreement, the National Packaging Protocol, and the Responsible Care Program adopted by the Canadian Chemical Producers' Association.

Expenditures to improve employee health, workplace safety and site beautification are excluded. Business environmental protection expenditures are broken down according to the following categories:

Environmental monitoring: expenditures for purchase of equipment, supplies, labour and services required to monitor pollutant emissions that would affect air, water or soil quality;

Environmental assessments and audits: expenditures made to review current operations' compliance with regulations and to evaluate the environmental impact of proposed projects;

Site reclamation and decommissioning: expenditures for clean-up of environmental damage and for closing a site;

Wildlife and habitat protection: expenditures made to protect wildlife and habitat from the effects of economic activity and to restore stocks that have been adversely affected by such activity;

Waste management and sewerage services;

End-of-pipe processes for pollution abatement and control: expenditures related to funding of processes whose sole purpose is to abate or control undesirable substances emitted during normal production activities, without any incidence on the production process itself;

Integrated processes for pollution abatement and control: expenditures made to develop a new or significantly modified production process in order to prevent or reduce the generation of waste;

Environmental fees, fines and licences; and

Other environmental protection: expenditures for administration of environmental projects, for training, and for other initiatives not elsewhere specified.

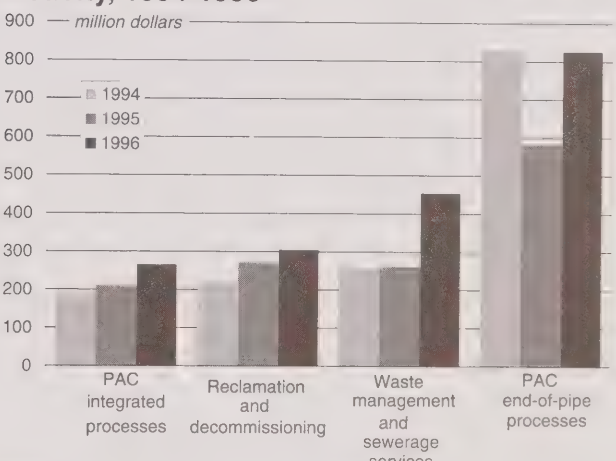
Environmental protection expenditures by business[1]

Text Box 7.2.3 provides a list of various categories of environmental protection expenditures by business. Such expenditures were estimated at $4.9 billion in 1996. Some 61% of these expenditures pertained to operating expenses. The lion's share of environmental protection expenditures applied to setting up or maintaining end-of-pipe PAC equipment and facilities. In other words, this involved procedures aimed at treating pollutants after they were emitted (Figures 7.2.5 and 7.2.6).

Operating expenditures for environmental protection

The Primary Metal Industry incurred the highest operating expenditures for environmental protection during the 1994–96 period as a whole. The Pulp and Paper Industry came in second (except in 1994). Both industries experienced their steepest operating expense increases in 1996 (Table 7.2.6). End-of-pipe processes were responsible for the highest environmental protection operating expenditures.

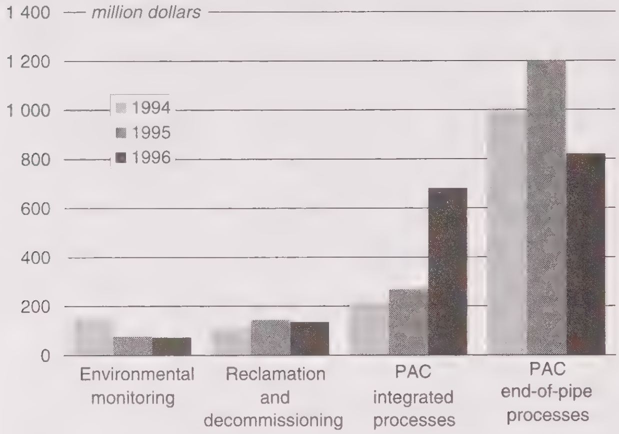
Figure 7.2.5
Business Operating Expenditures for Environmental Protection by Environmental Activity, 1994-1996



Note:
Data are taken from the Survey of Environmental Protection Expenditures and cover the following industries: Manufacturing (excluding the Other Manufacturing category in 1995 and 1996—see Table 7.2.6); Logging; Mining; Crude Petroleum and Natural Gas; Pipeline Transport; Gas Distribution Systems; and Electric Power Systems
Sources:
Statistics Canada, 1996, *Environmental Protection Expenditures in the Business Sector, 1994*, Catalogue No. 16F006XIE, Ottawa, December.
Statistics Canada, 1998, *Environmental Protection Expenditures in the Business Sector 1995*, Catalogue No. 16F006XIE, Ottawa, July.
Statistics Canada, Environment Accounts and Statistics Division

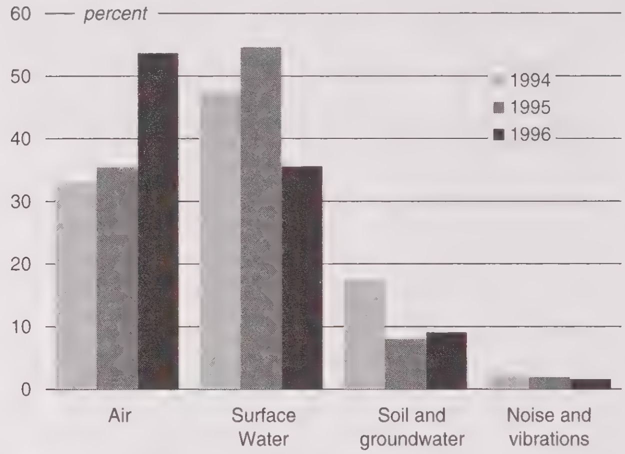
1. Data are taken from the Survey of Environmental Protection Expenditures from 1994 to 1996. This survey covered industries appearing in Tables 7.2.6 and 7.2.7.

Figure 7.2.6
Investment Spending on Environmental Protection by Activity, 1994-1996



Note:
Data are taken from the Survey of Environmental Protection Expenditures and cover the following industries: Manufacturing (excluding the Other Manufacturing category in 1995 and 1996—see Table 7.2.7); Logging; Mining; Crude Petroleum and Natural Gas; Pipeline Transport; Gas Distribution Systems; and Electric Power Systems.
Sources:
Statistics Canada, 1996, *Environmental Protection Expenditures in the Business Sector, 1994*, Catalogue No. 16F006XIE, Ottawa, December.
Statistics Canada, 1998, *Environmental Protection Expenditures in the Business Sector, 1995*, Catalogue No. 16F006XIE, Ottawa, July.
Statistics Canada, Environment Accounts and Statistics Division.

Figure 7.2.7
Investment Spending on Pollution Abatement and Control by Environmental Medium, 1994-1996



Note:
Data are taken from the Survey of Environmental Protection Expenditures and include the following industries: Manufacturing; Logging; Mining; Crude Petroleum and Natural Gas; Pipeline Transport; Gas Distribution Systems; and Electric Power Systems.
Sources:
Statistics Canada, 1996, *Environmental Protection Expenditures in the Business Sector, 1994*, Catalogue No. 16F006XIE, Ottawa, December.
Statistics Canada, 1998, *Environmental Protection Expenditures in the Business Sector, 1995*, Catalogue No. 16F006XIE, Ottawa, July.
Statistics Canada, Environment Accounts and Statistics Division.

Investment spending on environmental protection

At $1.9 billion, business investment spending on environmental protection accounted for 0.2 % of GDP in 1996. Pollution abatement and control was responsible for the major share of that investment (Tables 7.2.9 and 7.2.10). End-of-pipe investment fell 31.7% from 1995 to 1996, in favour of investment in pollution prevention methods. The latter included changes in business production processes, making it possible to cut quantities of materials used or to recycle wastes. Expenditures on capital aimed at making such integrated process changes more than doubled between 1995 and 1996, surging from $268.9 million to $681.8 million (Figure 7.2.6 and Table 7.2.7).

The Pulp and Paper Industry paid out the largest share of investment spending on environmental protection. It was followed by the Primary Metals Industry (Table 7.2.7). However, Pulp and Paper investment dropped by $171.5 million between 1995 and 1996 (mainly for end-of-pipe projects), despite a steep investment increase in integrated processes. Investment by Crude Petroleum and Natural Gas came second, followed by investment spending in Primary Metals. The latter doubled from 1995 to 1996 because of increased demand for integrated production process changes.

Investment spending by environmental medium

Figure 7.2.7 illustrates major changes between 1994 and 1996 in terms of investment distribution by environmental medium. In 1996, the majority of investment spending on PAC processes involved projects aimed at reducing air emissions (53.7%). In 1994 and 1995, on the contrary, about half such expenditures involved discharges into surface waters. By comparison, reduced surface water pollution was responsible for 35.6% of 1996 PAC investment spending.

Such changes are partly explained by the conclusion of Pulp and Paper's major investment cycle in wastewater treatment facilities and processes.[1] Nearly half a billion dollars less was spent in 1996 on surface water protection than in 1995. Almost $300 million was devoted instead to projects aimed at cutting air pollution. Certain smelters also made new investments of more than $100 million aimed at modernizing their facilities to prevent atmospheric emissions.

1. This investment cycle was prompted by federal and provincial environmental regulations.

Table 7.2.6

Operating Expenditures on Environmental Protection by Industry and Type of Activity, 1994-1996

Industry	Environmental monitoring	Environmental assessments and audits	Reclamation and decommissioning	Wildlife and habitat protection	Waste management and sewerage services	PAC end-of-pipe processes	PAC integrated processes	Fees, fines and licences	Other	Total
	million dollars									
1994										
Logging	4.5	1.1	23.4	29.0	2.4	2.2	0.8	0.8	3.0	67.4
Mining	30.4	8.7	47.9	2.6	4.0	102.3	14.6	6.0	11.4	227.8
Crude Petroleum and Natural Gas; Refined Petroleum and Coal Products[1]	14.6	6.0	38.9	5.7	17.3	220.4	19.1	4.5	18.9	345.4
Food	9.6	12.3	3.1	0.3	39.8	11.3	1.5	4.5	3.6	86.1
Beverage	0.2	1.0	3.8	-	12.8	1.4	0.8	1.2	1.6	22.8
Pulp and Paper	59.9	5.9	11.5	3.1	22.6	101.6	45.5	7.3	15.9	273.3
Primary Metals	46.0	4.6	18.5	0.2	39.3	185.2	71.2	7.9	17.5	390.6
Fabricated Metal Products	6.0	1.2	3.8	-	15.8	14.9	0.2	0.3	1.2	43.6
Transportation Equipment[2]	5.5	2.7	9.8	0.7	47.2	24.1	4.0	0.6	12.5	107.0
Non-Metallic Mineral Products	3.9	1.1	5.3	0.2	8.0	6.3	1.3	1.5	3.7	31.3
Chemical and Chemical Products	35.2	8.1	24.4	0.6	36.1	74.2	7.8	1.1	13.0	200.6
Electric Power Systems; Gas Distribution Systems	19.9	28.6	26.6	26.0	12.4	84.2	19.6	7.7	39.2	264.2
Total	**235.9**	**81.3**	**217.2**	**68.4**	**257.7**	**828.1**	**186.2**	**43.6**	**141.6**	**2 060.0**
1995										
Logging	3.2	10.8	21.2	44.4	5.3	3.4	0.2	8.8	2.6	99.8
Mining	23.5	8.8	68.3	7.4	6.2	99.4	9.5	3.8	12.2	239.0
Crude Petroleum and Natural Gas	7.9	4.1	47.7	1.1	45.5	52.1	9.5	2.3	19.7	189.8
Food	7.6	3.2	2.0	0.5	41.6	19.7	2.3	3.4	2.0	82.3
Beverage	1.1	0.5	0.9	-	11.4	1.3	0.2	0.8	2.0	18.3
Pulp and Paper	68.9	7.5	8.0	6.1	27.7	117.4	31.3	12.3	23.3	302.5
Primary Metals	35.5	4.1	27.6	4.0	60.5	148.3	84.1	4.5	10.8	379.4
Non-Metallic Mineral Products	4.1	1.3	9.0	0.3	7.0	6.6	3.9	1.5	2.3	36.0
Refined Petroleum and Coal Products	4.4	0.6	34.7	x	7.7	50.3	x	x	3.8	102.1
Chemical and Chemical Products	26.6	7.7	23.4	0.7	36.9	43.4	5.7	1.4	9.8	155.4
Other Manufacturing[2,3]	..	..	..	..	176.3	..	..	..	..	466.6
Pipeline Transport; Gas Distribution Systems	5.5	1.9	3.4	0.3	2.6	6.2	1.1	1.6	8.5	31.1
Electric Power Systems	8.7	19.3	25.7	x	9.8	35.2	x	x	79.8	283.6
Total excluding Other Manufacturing	**197.1**	**69.6**	**271.7**	**88.5**	**262.1**	**583.3**	**210.1**	**60.1**	**176.9**	**1 919.5**
Total	..	..	..	..	**438.4**	..	..	..	..	**2 386.1**
1996										
Logging	3.5	8.5	24.8	84.3	8.2	5.2	0.1	6.0	1.8	142.5
Mining	29.5	7.4	68.6	5.6	6.6	110.6	14.9	5.3	22.8	271.3
Crude Petroleum and Natural Gas	18.2	5.1	85.2	7.6	53.3	44.9	3.6	3.8	34.3	256.0
Food	9.3	2.7	4.9	1.5	46.7	23.2	3.1	4.8	4.6	100.7
Beverage	1.1	0.4	0.4	-	11.9	2.0	0.1	2.4	2.3	20.6
Pulp and Paper	92.1	12.6	7.6	18.0	37.8	199.0	31.8	9.6	21.3	429.8
Primary Metals	33.2	5.3	40.7	6.9	108.9	184.5	80.0	6.8	19.6	485.8
Transportation Equipment	5.2	2.1	4.7	0.1	67.6	31.9	3.7	0.8	9.7	125.8
Non-Metallic Mineral Products	4.2	1.5	5.3	0.1	7.5	6.8	0.3	2.5	3.3	31.5
Refined Petroleum and Coal Products	22.7	2.6	5.1	x	40.0	74.8	42.1	x	22.2	212.5
Chemical and Chemical Products	37.5	9.1	38.3	x	44.7	57.6	x	x	15.4	216.5
Other Manufacturing[3]	..	..	..	..	133.3	..	..	..	..	357.7
Pipeline Transport; Gas Distribution Systems	1.4	2.6	5.7	x	2.4	9.0	-	x	12.6	35.7
Electric Power Systems	8.8	22.5	13.4	x	18.8	77.0	x	42.0	23.5	297.6
Total excluding Other Manufacturing	**266.8**	**82.3**	**304.6**	**142.7**	**454.4**	**826.5**	**265.8**	**89.7**	**193.3**	**2 626.0**
Total	..	..	..	..	**587.7**	..	..	..	..	**2 983.8**

Notes:

Figures may not add up to totals due to rounding.

In 1994, the industry coverage was more restrictive.

1. In 1994, these two industries were combined for confidentiality of data.
2. Includes the following industries in 1994: Aircraft and Aircraft Parts; Motor Vehicles; Motor Vehicle Parts and Accessories; and Truck and Bus Body and Trailer. In 1995, Transportation Equipment is included in Other Manufacturing because of data quality constraints.
3. Includes all other manufacturing industries not already specified.

Sources:

Statistics Canada, 1996, *Environmental Protection Expenditures in the Business Sector, 1994*, Catalogue No. 16F006XIE, Ottawa, December.

Statistics Canada, 1998, *Environmental Protection Expenditures in the Business Sector, 1995*, Catalogue No. 16F006XIE, Ottawa, July.

Statistics Canada, Environment Accounts and Statistics Division.

Table 7.2.7

Investment Expenditures on Environmental Protection by Industry and Type of Activity, 1994-1996

Industry	Environmental monitoring	Environmental assessments and audits	Reclamation and decommissioning	Wildlife and habitat protection	PAC end-of-pipe processes	PAC integrated processes	Total
	million dollars						
1994							
Logging	0.5	--	1.6	4.0	1.5	1.0	8.6
Mining	8.4	0.6	27.8	1.1	42.5	20.2	100.6
Crude Petroleum and Natural Gas; Refined Petroleum and Coal Products[1]	20.8	14.4	44.4	2.1	189.8	34.4	305.9
Food	6.6	0.3	1.2	--	13.6	12.5	34.2
Beverage	--	--	3.5	-	4.0	14.1	21.7
Pulp and Paper	81.5	0.7	3.3	1.0	469.8	57.0	613.3
Primary Metals	2.3	x	0.7	x	63.8	18.2	87.0
Fabricated Metal Products	4.1	0.1	0.1	--	2.3	1.4	8.1
Transportation Equipment[2]	1.1	0.3	2.9	--	9.6	21.2	35.0
Non-Metallic Mineral Products	2.8	x	0.2	x	13.6	3.1	20.3
Chemical and Chemical Products	8.4	0.1	6.5	0.1	48.7	20.4	84.2
Electric Power Systems; Gas Distribution Systems	9.5	36.2	17.9	45.1	140.6	12.8	262.1
Total	**145.9**	**55.1**	**109.9**	**54.2**	**999.7**	**216.2**	**1 581.0**
1995							
Logging	0.1	x	0.2	x	3.3	0.6	7.9
Mining	11.0	0.6	21.7	0.1	45.6	5.4	84.5
Crude Petroleum and Natural Gas	3.2	5.9	82.1	1.1	209.1	16.5	317.9
Food	2.4	x	0.8	x	13.1	7.8	24.4
Beverage	1.4	0.1	0.7	--	1.6	3.7	7.5
Pulp and Paper	11.3	2.2	6.6	3.8	670.0	128.5	822.3
Primary Metals	7.2	0.5	0.3	0.1	55.6	45.8	109.5
Non-Metallic Mineral Products	2.3	0.2	0.9	0.4	42.6	6.4	52.8
Refined Petroleum and Coal Products	16.1	0.5	0.3	-	67.1	12.4	96.5
Chemical and Chemical Products	10.5	0.2	16.8	0.9	34.7	20.2	83.3
Other Manufacturing[2,3]	..	..	..	..	..	..	308.0
Pipeline Transport; Gas Distribution Systems	2.8	2.1	4.1	1.7	13.4	5.5	29.7
Electric Power Systems	9.4	x	10.4	x	47.4	16.1	146.0
Total excluding Other Manufacturing	**77.7**	**38.0**	**144.9**	**49.3**	**1 203.5**	**268.9**	**1 782.3**
Total	..	..	..	..	..	..	**2 090.3**
1996							
Logging	0.4	0.3	1.4	1.9	10.1	1.3	15.4
Mining	1.7	1.5	11.1	0.4	49.2	13.6	77.5
Crude Petroleum and Natural Gas	6.7	3.8	79.5	3.7	158.4	18.5	270.6
Food	1.7	x	0.1	x	37.4	29.1	68.3
Beverage	2.1	0.2	0.7	-	3.5	1.6	8.0
Pulp and Paper	16.9	2.4	13.7	1.4	297.4	319.0	650.8
Primary Metals	5.3	x	0.7	x	61.8	180.5	248.3
Transportation Equipment	0.8	0.2	3.3	0.7	25.3	31.0	61.4
Non-Metallic Mineral Products	2.0	x	1.3	x	33.6	6.3	43.2
Refined Petroleum and Coal Products	3.1	3.6	4.5	-	42.1	44.4	97.7
Chemical and Chemical Products	24.6	0.4	6.5	0.1	45.1	17.2	93.9
Other Manufacturing[3]	..	..	..	..	..	..	135.0
Pipeline Transport; Gas Distribution Systems	0.8	2.8	7.4	2.3	20.6	11.6	45.6
Electric Power Systems	7.0	22.4	6.4	16.9	37.0	7.9	97.6
Total excluding Other Manufacturing	**73.3**	**40.1**	**136.5**	**27.6**	**821.4**	**681.8**	**1 780.7**
Total	..	..	..	..	..	..	**1 915.8**

Notes:

Figures may not add up to totals due to rounding.

In 1994, the industry coverage was more restrictive.

1. In 1994, these two industries were combined for confidentiality of data.
2. Includes the following industries in 1994: Aircraft and Aircraft Parts; Motor Vehicles; Motor Vehicle Parts and Accessories; and Truck and Bus Body and Trailer. In 1995, Transportation Equipment is included in Other Manufacturing because of data quality constraints.
3. Includes all other manufacturing industries not already specified.

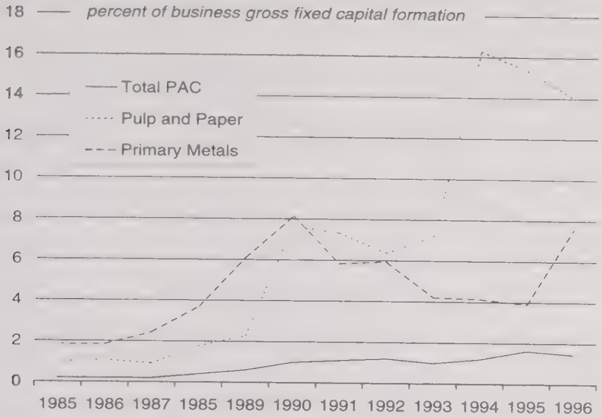
Sources:

Statistics Canada, 1996, *Environmental Protection Expenditures in the Business Sector, 1994*, Catalogue No. 16F006XIE, Ottawa, December.

Statistics Canada, 1998, *Environmental Protection Expenditures in the Business Sector, 1995*, Catalogue No. 16F006XIE, Ottawa, July.

Statistics Canada, Environment Accounts and Statistics Division.

Figure 7.2.8
Business Investment Spending on Pollution Abatement and Control for Selected Industries,[1] 1985-1996



Notes:
Business investment spending on pollution abatement and control (PAC) is derived from the Capital and Repairs Expenditures Survey from 1985 to 1993. Since 1994, most of the PAC investment is estimated from the Survey of Environmental Protection Expenditures. Because of that break in the series, estimates of PAC investment in Pulp and Paper before 1994 may include some investment by other Paper and Allied Products industries.
The following industries are excluded: Agriculture; Fishing and Trapping; Education Service; and Health and Social Services.
1. Total business investment spending on PAC is expressed as a percentage of business gross fixed capital formation. For the Pulp and Paper and Primary Metals industries, investment in PAC is expressed as a percentage of total capital and repairs expenditures in the respective industry (for Pulp and Paper, the denominator used is capital and repairs expenditures in the Paper and Allied Products group, from 1985 to 1993).
Sources:
Statistics Canada, Environment Accounts and Statistics Division, Investment and Capital Stock Division, and CANSIM, series D15674.

Table 7.2.8
Business Investment Spending on Pollution Abatement and Control, 1985-1996

Year	Investment on pollution abatement and control	Business gross fixed capital formation (GFCF)	PAC investment as a proportion of GFCF
	million dollars		percent
1985	141	82 009	0.2
1986	193	89 228	0.2
1987	224	103 752	0.2
1985	487	117 963	0.4
1989	784	127 964	0.6
1990	1 266	121 750	1.0
1991	1 240	111 134	1.1
1992	1 245	108 209	1.2
1993	1 081	107 536	1.0
1994	1 450	118 992	1.2
1995	1 897	117 291	1.6
1996	1 811	124 978	1.4

Notes:
Business investment spending on pollution abatement and control (PAC) is derived from the Capital and Repairs Expenditures Survey from 1985 to 1993. Since 1994, the majority of PAC investment is estimated from the Survey of Environmental Protection Expenditures.
Since estimates of PAC investment for the 1985-93 and the 1994-96 periods are derived from different sources, comparisons between the two periods should be made with caution.
The following industries are excluded: Agriculture; Fishing and Trapping; Education Service; and Health and Social Services.
Sources:
Statistics Canada, Environment Accounts and Statistics Division, Investment and Capital Stock Division, and CANSIM, series D15674.

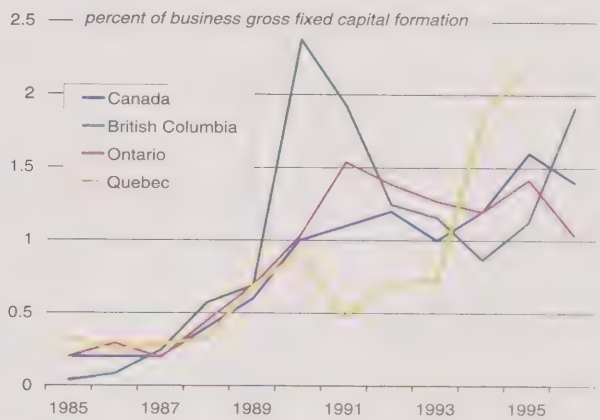
The increased significance of investment spending aimed at protecting the atmosphere results, to a certain extent, from goals developed as part of voluntary environmental accords like the Accelerated Reduction/Elimination of Toxics (ARET) program and the Kyoto Protocol (see sections 7.1–**Environmental legislation and non-regulatory initiative** and 7.4–**Environmental practices**).

Business investment spending on pollution abatement and control[1]

How significant is environmental protection in the total budget of a company? As shown in Table 7.2.8 and Figure 7.2.9, even though the cost of environmental compliance to businesses represents less than 2% of their gross fixed capital formation over time, businesses invest more in preventing and abating pollution than they have in the past. PAC share of total business gross fixed capital formation was generally on the rise between 1985 and 1995, though the rate of growth changed over the years. In 1996, that share actually declined to 1.4%.[2]

1. Figures presented here include estimates of PAC investment for non-manufacturing industries not covered in the Survey of Environmental Protection Expenditures ($115.4 million in 1996).

Figure 7.2.9
Business Investment Spending on Pollution Abatement and Control for Selected Provinces, 1985-1996



Notes:
Business investment spending on pollution abatement and control (PAC) is derived from the Capital and Repairs Expenditures Survey from 1985 to 1993. Since 1994, most of the PAC investment is estimated from the Survey of Environmental Protection Expenditures For confidentiality reasons, estimates for Quebec for 1996 are not shown.
The following industries are excluded: Agriculture; Fishing and Trapping; Education Service; and Health and Social Services.
Sources:
Statistics Canada, Environment Accounts and Statistics Division, Investment and Capital Stock Division, and CANSIM, series D31820, D24341,D31842, D24375,D44024 and D24511.

PAC share of total business investment spending varies with the industry. For instance, PAC accounted for 14.0% of total investment in Pulp and Paper and 7.5% in Primary Metals in 1996, while the business sector as a whole

invested a much smaller share in PAC (Figure 7.2.8). The two industries were responsible for the largest PAC investment (Table 7.2.9).

Moreover, in the Pulp and Paper Industry, PAC investment share increased dramatically in the mid-1990s, averaging 15.2% over the 1994–96 period. The Pulp and Paper Industry was subject to strict environmental regulations on its effluents and air emissions in the 1990s. Compliance to federal and provincial regulations on effluents, for instance, was scheduled for 1995, explaining the larger share of PAC investment prior to 1996[1] (Figure 7.2.8). By 1996, pulp and paper mills were equipped with wastewater treatment facilities and equipment, explaining the subsequent decline in PAC investment.

PAC share of business gross fixed capital formation varies according to the province or territory (Figure 7.2.9 and Table 7.2.10). Observed differences may be partly the result of differences in provincial environmental regulations and deadlines for compliance.

2. In comparison, PAC investment made by local governments represented 14% of local government gross fixed capital formation in 1996 (Figure 7.2.2).
1. Some examples of regulations pertaining to the Pulp and Paper Industry include the following: *Quebec's Pulp and Paper Sector Decree*, which falls under Quebec's *Environmental Quality Act*; *Pulp and Paper Effluent Regulations* under the federal *Fisheries Act*; *Pulp and Paper Mill Effluent Chlorinated Dioxins and Furans Regulations* and *Pulp and Paper Mill Defoamer and Wood Chip Regulations*, both under the *Canadian Environmental Protection Act* (Earl, L. and J. Bainbridge, 1998, *Canada's Environmental Legislation, 1998 Edition*, Toronto, Templegate Information Services Inc.).

Table 7.2.9

Business Investment Spending on Pollution Abatement and Control by Industry, 1985-1996

Industry	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
						million dollars						
Forestry	x	-	-	0.1	x	x	0.7	x	x	3.0	4.0	11.7
Mining[1]	..	..	40.8	87.8	51.8	78.0	71.5	64.4	58.1	71.1	62.0	64.5
Crude Petroleum and Natural Gas[1]	...	...	...	...	...	...	...	...	...	139.3	228.8	183.6
Food and Beverage	x	x	12.8	5.0	x	x	9.7	33.5	15.1	50.8	29.9	75.3
Pulp and Paper[2]	31.2	35.7	37.8	95.4	171.6	489.8	400.1	278.5	281.8	608.3	809.7	633.3
Primary Metals	54.5	57.7	73.4	121.4	258.5	395.8	259.9	198.9	107.5	84.3	108.6	247.6
Fabricated Metal Products[3]	4.9	7.5	7.5	7.8	10.8	6.0	x	x	x	7.8	..	..
Transportation Equipment[4]	2.0	19.6	5.2	16.3	15.5	14.0	15.7	1.9	10.5	31.8	..	57.1
Non-Metallic Mineral Products	2.5	3.7	x	3.3	4.1	1.6	x	x	x	19.5	51.4	41.9
Refined Petroleum and Coal Products	1.2	x	3.0	3.2	x	12.7	17.9	16.4	23.0	105.7	95.6	89.6
Chemical and Chemical Products	11.6	31.4	24.1	31.1	124.0	29.1	37.8	69.0	77.4	77.4	65.5	86.9
Other manufacturing industries[5]	3.1	10.8	7.0	9.3	20.8	26.8	26.3	23.2	14.3	28.1	301.9	118.8
Electric Power and Gas Distribution Systems; Other Utilities[6]	x	2.5	x	64.9	99.3	177.0	378.1	504.8	457.7	163.0	94.6	85.0
Other non-manufacturing industries[7]	19.5	18.3	8.4	41.1	9.5	9.8	15.2	49.4	26.6	60.0	45.3	115.4
Total	**140.6**	**193.0**	**224.2**	**486.7**	**784.3**	**1 265.9**	**1 240.1**	**1 245.3**	**1 080.8**	**1 449.9**	**1 897.3**	**1 810.7**

Notes:
Figures may not add up to totals due to rounding.
Data from 1985 to 1993 are derived from the Capital and Repairs Expenditures Survey (CRES).
Data from 1994 to 1996 are derived from the Survey of Environmental Protection Expenditures, except for 'Other non-manufacturing industries' (and Other manufacturing industries in 1994).
Since PAC investment data for the 1985-93 and 1994-96 periods are derived from different data sources, any comparison between the two periods should be made with caution.
The following industries are excluded: Agriculture; Fishing and Trapping; Education Service; and Health and Social Services.
1. From 1987 to 1993, data for Mining and for Crude Petroleum and Natural Gas were combined.
2. Before 1994, data for Pulp and Paper may include investment from other Paper and Allied Products industries as well.
3. In 1995 and 1996, Fabricated Metal Products was included in Other Manufacturing Industries.
4. In 1995, Transportation Equipment was included in Other Manufacturing Industries.
5. Data for Other Manufacturing Industries were derived from CRES before 1995.
6. Since 1995, these industries include Pipeline Transport.
7. Estimates for 'Other non-manufacturing industries' are derived from CRES.
Sources:
Statistics Canada, Environment Accounts and Statistics Division, and Investment and Capital Stock Division.

Table 7.2.10

Business Investment Spending on Pollution Abatement and Control by Province and Territory, 1985-1996

Year	Canada	Nfld.	P.E.I.	N.S.	N.B.	Que.	Ont.	Man.	Sask.	Alta.	B.C.	Y.T. and N.W.T
						million dollars						
1985	**140.6**	x	x	x	1.9	55.2	59.4	x	0.4	9.8	3.4	x
1986	**193.0**	2.6	x	6.4	3.3	48.0	107.0	1.7	1.6	15.5	6.9	x
1987	**224.2**	9.3	x	x	11.8	69.7	84.8	3.1	3.5	7.8	25.2	x
1988	**486.7**	x	x	9.7	25.3	85.7	226.2	14.2	5.9	23.6	73.4	16.1
1989	**784.3**	x	x	x	13.1	195.0	386.8	10.7	8.2	44.1	113.4	x
1990	**1 265.9**	20.2	x	6.1	9.4	255.9	501.3	x	x	25.4	399.5	9.3
1991	**1 240.1**	x	x	x	x	121.5	678.6	5.6	24.2	24.6	327.9	x
1992	**1 245.3**	x	x	x	78.4	159.5	577.4	12.3	x	84.6	212.6	x
1993	**1 080.8**	x	x	18.2	31.1	163.3	481.9	18.2	x	128.8	206.0	x
1994[1]	**1 449.9**	..	..	..	95.6	438.7	488.9	..	..	251.1	174.0	..
1995	**1 897.3**	46.3	x	36.8	118.6	495.5	578.4	58.3	46.6	301.9	212.9	x
1996	**1 810.7**	43.9	x	x	82.8	x	472.0	24.5	40.8	278.0	349.0	x

Notes:

Figures may not add up to totals due to rounding.

Data from 1985 to 1993 are derived from the Capital and Repairs Expenditure Survey.

Data from 1994 to 1996 are derived for the most part from the Survey of Environmental Protection Expenditures.

Since PAC investment data for the 1985-93 and 1994-96 periods are derived from different data sources, any comparison between the two periods should be made with caution.

The following industries are excluded: Agriculture; Fishing and Trapping; Education Service; and Health and Social Services.

1. A regional breakdown was provided for the 1994 data. Because of data confidentiality, figures for New Brunswick cover all the Atlantic provinces (Newfoundland, Prince Edward Island, Nova Scotia and New Brunswick) while figures for Alberta cover all the Prairie provinces (Manitoba, Saskatchewan, Alberta), the Yukon Territory and the Northwest Territories.

Sources:

Statistics Canada, Environment Accounts and Statistics Division, and Investment and Capital Stock Division.

7.3 The environment industry

Many Canadian businesses have adopted environmentally friendly production processes to limit the impact that their operations have on the environment. This has given rise to businesses specializing in the development and provision of goods and services—such as energy-saving devices, wastewater treatment systems, and water reuse systems—that help to prevent, reduce or remediate environmental degradation.[1] These businesses are referred to collectively as the 'environment industry'[2] (Text Box 7.3.1).

7.3.1 Environment industry revenues

In 1995, the total value of environmental goods and services produced was $19.4 billion. Businesses were the major producers, supplying $10.2 billion of these goods and services. The rest came from three other sources: $4.9 billion was provided by government; $1.7 billion was produced by businesses for internal use (called 'business own account'); and $2.6 billion was imported.[3]

Business sales of environmental goods and services[4]

Of the $10.2 billion in business revenues from environment-related production, sales of environmental goods accounted for 41%, environmental services 38%, and construction services 20% (Table 7.3.1).[5] Exports of these goods and services amounted to $539.7 million, while imports totalled $1.2 billion (Table 7.3.5). The environmental goods and services firms employed 149 957 persons overall, three-quarters of whom worked in service industries.

Revenues by type of environmental good and service

Environmental revenues can be broken down by type of good or service. Of the $10.2 billion, goods accounted for $4.2 billion, services for $3.9 billion and environment-related construction $2.0 billion (Table 7.3.1).

1. Industry Canada, 1998, *Sector Competitiveness Frameworks Series, Environment Industry,* Ottawa.
2. Although the environment industry does not exist as a formal industry within the Standard Industrial Classification (SIC) system or the North American Industrial Classification System (NAICS), the term is used here to denote those businesses that produce or supply environmental goods or services, or engage in environment-related construction activities.
3. Statistics Canada, Environment Accounts and Statistics Division.
4. Although governments also provide environmental goods and services, this section presents data on the business sector of the industry.
5. The total revenues of businesses in the environment industry, which include both environmental and non-environmental revenues, were $19.4 billion in 1995. Coincidentally, this figure is the same as the total environmental revenue produced by the environment industry as a whole ($19.4 billion).

Text Box 7.3.1
Defining the Environment Industry

Defining the environment industry is a challenge. An industry can be defined as a group of establishments whose production represents a homogeneous set of goods or services, or as a group of establishments engaged in the same or similar economic activities. According to this definition, the environment industry *per se* does not exist because its economic activities (i.e., products and/or their production processes) can be quite diverse.

However, when defining industries based on the use of the product by the consumer rather than on the production process, it becomes possible to identify an 'environment industry.' The following is Statistics Canada's definition, based on an international convention developed by the Organisation for Economic Co-operation and Development (OECD)/Eurostat Informal Working Group on the Environment Industry:[1] those firms which produce goods or provide services (including construction activities) that contribute to the prevention, measurement, abatement or remediation of degradation to the air, land, soil and water. Also included are waste management services related to the collection, transportation, storage and refinement of materials that may be harmful to the environment.[2]

On the basis of this definition, 27 industries[3] have been identified as carrying out some activity related to protecting the environment in Canada. These are grouped together into the 'environment industry.'

A difficulty with Statistics Canada's definition is identifying goods and services related to the environment. In other words, what distinguishes an 'environmental' good or service from a 'non-environmental' one? Certain products have several uses. Furthermore, many businesses do not know whether their products are used for environmental purposes. One example is a water valve, which could be used for an environmental purpose (e.g., in a wastewater treatment process) or a non-environmental purpose (e.g., in a fire sprinkler system).

To help identify 'environmental' production, detailed lists of environmental goods, environmental services and environment-related construction have been developed (Text Box 7.3.2).

1. The OECD defines the environment industry as activities which produce goods or services to measure, prevent, limit or correct environmental damage to water, air and soil, as well as problems related to waste, noise and ecosystems.
2. Organisation for Economic Co-operation and Development (OECD), 1996, *Interim Definition and Classification of the Environment Industry,* OECD/Eurostat Informal Working Group on the Environment Industry, Paris.
3. As defined at the two-digit level of the 1980 Standard Industrial Classification.

Table 7.3.1
Total Business and Business Environmental Revenues and Total Business Employment[1] by Industry,[2] 1995

Industry	Firms	Total employment	Total revenues	Environmental revenues: Goods	Services	Construction	Total
	number		million dollars				
Services to agriculture and to mining	22	1 412	154.6	51.3	17.6	-	68.9
Other primary industries	12	807	64.0	22.0	18.0	-	40.0
Rubber	8	146	18.0	12.5	-	-	12.5
Plastics	35	2 177	373.1	153.3	2.3	0.7	156.3
Textile products	8	212	25.0	12.2	0.9	-	13.1
Wood	5	715	153.7	10.2	x	x	10.5
Primary metals	11	1 087	237.9	24.4	x	x	47.6
Fabricated metals	35	4 136	859.2	107.4	0.1	-	107.5
Machinery	83	3 176	552.6	364.3	25.2	4.1	393.6
Transportation equipment	12	1 442	229.6	134.2	19.5	-	153.7
Electrical	18	942	176.5	27.2	16.3	2.5	46.1
Non-metallic minerals	11	537	80.6	56.9	-	-	57.0
Chemical	35	2 607	550.4	80.2	15.2	-	95.4
Other manufacturing	38	1 888	345.5	147.5	4.9	-	152.4
Other goods	12	424	64.1	14.2	15.7	-	29.9
Construction: building	12	327	49.4	14.1	5.2	8.8	28.2
Construction: engineering[3]	...	12 969	1 990.3	1.3	8.0	1 981.1	1 990.3
Construction: trade contracting	30	1 597	232.3	27.8	19.0	9.1	55.9
Transportation	4	249	16.3	2.2	1.3	--	3.5
Waste management industry	1 540	39 568	2 903.4	2.7	2 635.0	--	2 638.3
Wholesale: hardware, plumbing, heating	13	333	66.2	26.4	x	x	28.3
Wholesale: machinery and equipment	62	1 434	384.6	169.0	28.4	8.9	206.3
Wholesale: other (including scrap metal)	1 511	14 102	2 668.9	2 606.5	0.8	-	2 607.3
Holding and investment companies	8	4 554	859.8	29.4	2.6	-	32.0
Business services:							
Computer services	24	433	39.1	14.1	5.5	-	19.6
Consulting engineering	492	28 617	3 175.4	36.4	592.0	6.2	634.6
Scientific and technical services	256	7 103	540.4	23.6	304.8	3.0	331.4
Lawyers	29	5 105	614.6	-	14.0	-	14.0
Management consulting	57	1 413	148.2	6.7	29.9	5.7	42.3
Other business services	37	5 812	612.5	4.7	23.6	4.1	32.4
Health and social services	16	300	17.9	-	x	x	5.5
Other services[4]	15	240	22.9	4.8	7.4	1.3	13.4
Other services, not classified	28	1 776	131.7	9.3	21.5	0.1	30.7
Not classified	194	2 317	939.4	27.5	58.4	8.9	94.7
Canada	**4 673[5]**	**149 957**	**19 409.1**	**4 223.9**	**3 920.2**	**2 049.0**	**10 193.1**

Notes:
Figures may not add up to totals due to rounding.
1. Represents all employment related to the production of both environmental and non-environmental goods.
2. Only those firms that reported revenues from the sale of environmental goods, services or environment-related construction activities are included in these data.
3. These data were derived from demand side estimates of total environmental revenue. The total number of firms and the construction industry's total revenues (environmental and non-environmental) were not included in these estimates.
4. Includes rental of machinery and equipment.
5. The total number of firms in this table does not include 'Construction: engineering' firms because of the methodology used to derive the estimates.
Source:
Statistics Canada, Environment Accounts and Statistics Division.

Scrap material revenues accounted for 62% of total environmental goods sales in 1995 (Figure 7.3.1). This was followed by goods used for water supply and conservation and wastewater treatment, which accounted for almost 15% of the total.

Within environmental services, waste management services generated 69% of total revenues in 1995 (Figure 7.3.2). Businesses in this industry include firms that pick up garbage and recyclable materials (e.g., blue box materials) from households and businesses; firms that sort recyclable materials; and firms that manage other types of waste. Engineering services accounted for the next highest source of services revenues with 21% of the total in 1995.

Environmental revenues by industry

Four industry groups accounted for 81% of total environmental revenues in 1995 (Figure 7.3.3). Waste management[1] and scrap material dealers were the highest earners, reporting 26% and 25% of total revenues respectively. In 1995, construction earned 20% and business services 11% of total environmental revenues.

1. For more information about Canada's waste management industry, see Statistics Canada, 1998, *Waste Management Industry Survey: Business Sector, 1995*, Catalogue No. 16F0003XIE, Ottawa.

Text Box 7.3.2

Detailed Product Categories of Environmental Goods and Services and Environment-related Construction

Environmental goods

- ***Air pollution control*** – air-handling equipment; catalytic converters; chemical recovery systems; dust collectors; separators/precipitators; incinerators; scrubbers; odour control equipment
- ***Water supply and conservation*** – potable water; water-handing goods and equipment (pumps, pipes, valves); water conservation products (low-flow toilets, shower heads)
- ***Wastewater treatment*** – aeration systems; chemical recovery systems; biological recovery systems; gravity sediment systems; oil/water separation systems; screens/strainers; sewage treatment; water pollution control; wastewater reuse equipment; water treatment chemicals; water treatment equipment; clarifiers, filters and filter media; water purification equipment
- ***Solid and hazardous waste management*** – hazardous waste storage/treatment equipment; waste collection equipment; waste disposal equipment; waste-handling equipment; waste separation equipment; recycling equipment; incineration equipment
- ***Remediation/treatment of soil and groundwater*** – absorbents; bioremediation equipment; soil vapour extraction equipment; spill equipment; containment systems
- ***Noise/vibration abatement*** – mufflers/silencers; noise-deadening equipment; vibration control systems; highway barriers
- ***Environmental monitoring, analysis and assessment*** – measuring and monitoring equipment; sampling systems; process and control equipment; data acquisition equipment; other instruments/machines; software
- ***Energy-efficient products*** – energy management equipment; energy recovery equipment; alternate energy systems and equipment; insulation and sealing products; energy-efficient lighting, motors, etc.
- ***Renewable energy and alternative fuel systems*** – renewable energy systems and equipment (solar, wind, tidal, geothermal); alternative fuel systems and equipment
- ***Other goods*** – components of cleaner technologies, eco-efficient technologies, etc.

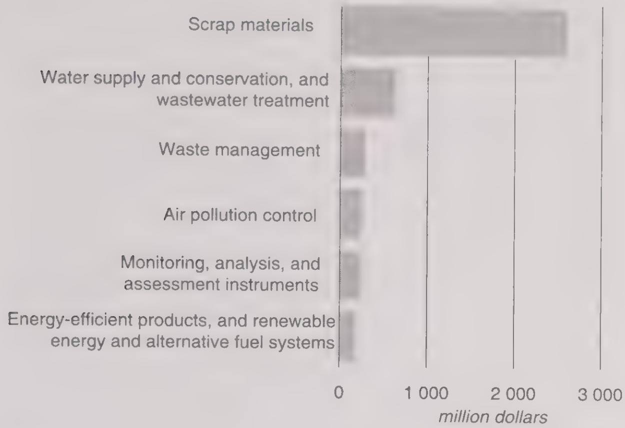
Environmental services

- ***Air pollution control*** – emission monitoring; assessment/evaluation; planning
- ***Water supply and conservation*** – water purification; water delivery; water-handling systems
- ***Wastewater management*** – sewage treatment systems; wastewater reuse systems; operation of water treatment facilities; storm water management; water and wastewater system assessment and design consulting
- ***Solid and hazardous waste management*** – emergency response and spills clean-up; water handling, collection, transport, transfer stations and disposal; operation of sites; ownership/management of sites; recycling (sorting, baling, cleaning); operation of recycling plants (material recovery facilities); hazardous waste management; medical waste management; nuclear waste management
- ***Remediation/treatment of soil and groundwater*** – clean-up; industrial services (cleaning for facilities and tanks); groundwater monitoring and remediation services; soil remediation services; hydro-geological services; site reclamation and remedial action services
- ***Noise/vibration abatement*** – assessment/monitoring
- ***Environmental contracting and engineering*** – engineering design/specifications/project management; biological/ecosystems studies; environmental impact assessment, audits; water treatment; environmental management planning; risk/hazard assessment; laboratory/field services; environmental economics
- ***Environmental research and development*** – clean processes; end-of-pipe pollution abatement and control
- ***Analytical services, data collection and analysis*** – measuring and monitoring; sampling; process and control; data acquisition
- ***Environmental education, training and information*** – environmental education and training; environmental information-searching services; environmental data management and analysis; ISO 9000/14000 support services
- ***Energy efficiency and renewable energy*** – energy audit; energy resource management; energy services; alternative energy system design; renewable energy services (site assessment, project development, installation); renewable energy production (solar, wind, tidal, geothermal, etc.)
- ***Other services*** – conservation/resource management; environmental public relations; environmental law; environmental risk management/liability insurance; marketing/advertising; business development; emergency response planning; full-cost accounting; public/private partnership development

Environment-related construction

- ***Air pollution control***
- ***Water supply and conservation***
- ***Wastewater management*** – sewer systems; water treatment plants
- ***Solid and hazardous waste management*** – hazardous waste management; solid waste treatment; storage and disposal; recycling
- ***Remediation/clean-up of soil and groundwater***
- ***Noise/vibration abatement*** – highway barriers
- ***Other*** – renewable energy (solar, wind, tidal, thermal, other); conservation (soil, water, wildlife, habitat); environment management systems (forest management, etc.)

Figure 7.3.1
Environmental Goods Revenues by Type, 1995



Note:
Refer to Text Box 7.3.2 for a definition of goods categories.
Source:
Statistics Canada, Environment Accounts and Statistics Division.

Most of the major environment industries derived their revenues from a single category of environmental goods or services in 1995. Also, the higher the environmental revenues, the more concentrated these revenues were within one specific environmental good or service. This was the case for scrap materials, waste management and construction. Among the major industries, only business services (itself an aggregate of several industries) earned revenues from a wide range of environmental services, with consulting engineering services accounting for the majority of these revenues (Table 7.3.1).

Environmental revenues by province

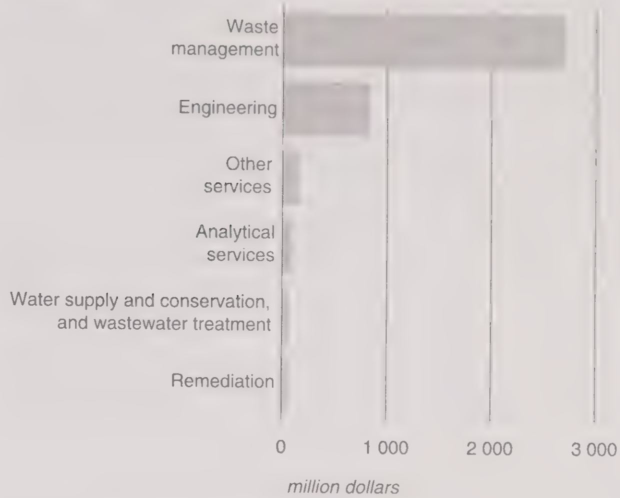
Ontario firms generated the highest environmental revenues in 1995. The province also accounted for 32% of all environmental firms, followed by 27% in Quebec, 14% in British Columbia and 9% in Alberta (Table 7.3.2).

In Canada, the share of environmental revenues for the goods, services and construction sectors were 41%, 38% and 20%, respectively. The pattern differed provincially, with goods revenues exceeding services revenues in only four provinces (New Brunswick, Quebec, Ontario and Saskatchewan), while construction revenues accounted for over 50% of all environment revenues in Newfoundland and the Yukon and Northwest Territories (Table 7.3.2).

Environmental revenues by firm size

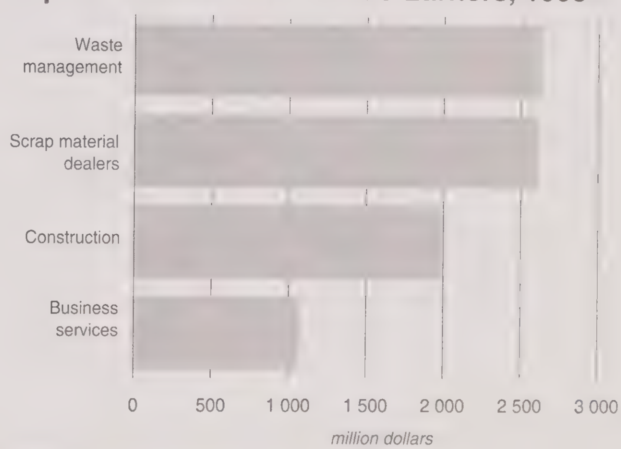
Businesses in the environment industry range from one-person operations to large multinational corporations. Small firms (those employing under 100 employees) made up 95% of the total number of businesses, medium-sized firms (100 to 499 employees) 4%, and large firms (500 or more

Figure 7.3.2
Environmental Services Revenues by Type, 1995



Notes:
Construction activities are not included.
Refer to Text Box 7.3.2 for a definition of services categories.
Source:
Statistics Canada, Environment Accounts and Statistics Division.

Figure 7.3.3
Top Environmental Revenue Earners, 1995



Source:
Statistics Canada, Environment Accounts and Statistics Division.

employees) 1%. Small firms accounted for 67% of all environmental revenues, while medium and large firms generated 23% and 10%, respectively (Table 7.3.3).

In 1995, small firms earned 59% of revenues for services, 60% for construction and 79% for environmental goods. Medium-sized businesses reported the second-highest receipts in the goods and services group, while large firms were second in the environment-related construction group.

7.3.2 Employment in the environment industry

The environment industry has created a demand for employees with specific skills and experience. Higher environmental standards for projects such as wastewater treatment facilities and solid waste landfills, as well as tougher environmental regulations, have increased the demand for skilled workers (Text Box 7.3.3).

In 1995, the Canadian environment industry accounted for almost 150 000 jobs. In addition, governments providing waste management services employed almost 8 000 people.[1] Disaggregated by industry, business services provided 32% of these jobs, waste management 26%, scrap metal dealers 10%, and construction engineering 9% (Table 7.3.1). Employment in the environment industry is compared with other major industry groups in Canada in Figure 7.3.4.

1. This figure is based on preliminary data obtained from Statistics Canada, 1998, *Waste Management Industry Survey: Government Sector, 1994,* Catalogue No. 16F0002XIE, Ottawa.

Environment industry employment by province

In 1995, Ontario firms accounted for 47% of the total national employment in the environment industry. Quebec firms employed 20% while those in British Columbia and Alberta followed with 12% and 11%, respectively (Table 7.3.2). Business services are the top employers in all provinces except Newfoundland and Ontario. The waste management industry is the second-most dominant industry in Nova Scotia, Quebec and British Columbia (Table 7.3.4).

Table 7.3.2

Total Business and Business Environmental Revenues and Total Business Employment[1] by Province and Territory, 1995

Province/Territory	Firms	Total employment	Total revenues	Environmental revenues: Goods	Services	Construction	Total
	number		million dollars				
Newfoundland	98	1 640	162.8	13.1	32.5	63.3	108.2
Prince Edward Island	23	341	26.1	3.3	12.0	8.5	23.8
Nova Scotia	214	3 120	352.3	50.8	97.8	50.9	199.4
New Brunswick	168	2 428	263.2	75.1	65.9	53.1	194.1
Quebec	1 240	30 197	4 443.3	1 236.0	930.6	487.8	2 654.4
Ontario	1 515	70 382	8 926.7	2 082.6	1 660.1	555.9	4 298.6
Manitoba	152	4 679	536.6	97.3	116.6	42.3	256.2
Saskatchewan	187	2 339	237.8	68.7	40.8	48.8	158.3
Alberta	424	16 783	1 921.6	195.0	442.5	411.7	1 049.1
British Columbia	634	17 806	2 511.3	401.8	511.3	314.9	1 228.0
Yukon and Northwest Territories	18	242	27.4	0.3	10.3	11.9	22.5
Canada	**4 673[2]**	**149 957**	**19 409.1**	**4 223.9**	**3 920.2**	**2 049.0**	**10 193.1**

Notes:
Figures may not add up to totals due to rounding.
1. Represents all employment related to the production of both environmental and non-environmental goods.
2. The total number of firms in this table does not include 'Construction: engineering' firms because of the methodology used to derive the estimates.
Source:
Statistics Canada, Environment Accounts and Statistics Division.

Table 7.3.3

Total Business and Business Environmental Revenues and Total Employment[1] by Firm Size, 1995

Firm size	Firms	Total employment	Total revenue	Environmental revenues: Goods	Services	Construction	Total
	number		million dollars				
0-4	2 171	5 238	638.4	261.7	218.5	110.3	590.5
5-9	762	5 801	818.3	312.8	250.5	145.4	708.6
10-24	792	12 965	1 805.0	715.4	588.1	172.8	1 476.4
25-49	504	19 020	2 843.9	1 319.4	553.2	387.9	2 260.5
50-99	239	19 043	2 689.3	714.5	690.6	416.0	1 821.1
100-499	176	34 912	5 298.0	721.9	1 271.7	290.3	2 283.8
500-999	21	15 748	2 060.8	156.4	340.4	252.3	749.1
1 000 or more	8	37 229	3 255.4	21.8	7.3	274.0	303.2
Canada	**4 673[2]**	**149 957**	**19 409.1**	**4 223.9**	**3 920.2**	**2 049.0**	**10 193.1**

Notes:
Figures may not add up to totals due to rounding.
1. Represents all employment related to the production of both environmental and non-environmental goods.
2. The total number of firms in this table does not include 'Construction: engineering' firms because of the methodology used to derive the estimates.
Source:
Statistics Canada, Environment Accounts and Statistics Division.

Text Box 7.3.3
Defining the Environmental Employee

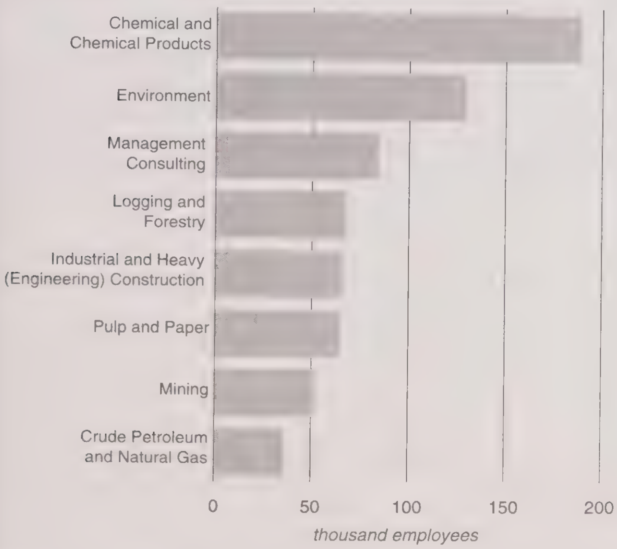
To provide standardization for required skills and training, the Canadian Council for Human Resources in the Environment Industry (CCHREI)[1] has categorized environmental employment into three sectors:

- environmental protection;
- conservation and preservation of natural resources; and
- environmental education, communication and research.[2]

These sectors are further divided into 15 subsectors and national occupation standards are detailed for each of them. Those who meet these standards are then eligible to become Certified Canadian Environmental Practitioners.

1. The Canadian Council for Human Resources in the Environment Industry is a not-for-profit corporation that assists the Canadian environmental sectors in implementing human resource development policies.
2. The Canadian Council for Human Resources in the Environment Industry, 1999, *Occupational Profiles,* <http://www.cchrei.ca/profiles/profiles.html>, (accessed September 28, 1999).

Figure 7.3.4
Employment in Selected Canadian Industries, 1995



Note:
There may be some double-counting of employees (e.g., some employees may be counted as part of both the environment industry and the Pulp and Paper Industry).
Sources:
Statistics Canada, Environment Accounts and Statistics Division, and CANSIM matrix 4285.

Table 7.3.4
Top Employers in the Environment Industry by Province and Territory, 1995

Province/Territory	Environment-related construction	Waste management	Scrap metal industry	Business services
	number of employees			
Newfoundland	622	288	137	518
Prince Edward Island	x	x	x	x
Nova Scotia	375	654	277	1 410
New Brunswick	354	329	442	710
Quebec	2 295	5 662	3 888	10 234
Ontario	3 801	7 390	5 982	17 243
Manitoba	408	293	468	1 984
Saskatchewan	504	277	420	625
Alberta	2 810	2 088	921	8 181
British Columbia	1 573	2 502	1 526	7 480
Yukon and Northwest Territories	x	x	x	x

Source:
Statistics Canada, Environment Accounts and Statistics Division.

7.3.3 Imports and exports of environmental goods

In 1995, Canada was a net importer of a number of environmental goods (Table 7.3.5).[1] Although these data represent only the import and export of environmental goods, preliminary data indicate that this trend is not unique to these products and also applies to environmental services.[2] The estimated global market for environmental goods and services will approach $1 trillion by the year 2000.[3]

Table 7.3.5
Exports and Imports of Selected Environmental Products, 1995

Goods	Total exports	Total imports	Net exports[1]
	million dollars		
Industrial or lab furnaces and ovens, including incinerators	6.3	20.7	-14.4
Filtering or purifying machinery and apparatus for water	82.3	77.1	5.2
Filtering or purifying machinery and apparatus for liquids	41.5	101.8	-60.3
Filtering or purifying machinery and apparatus for gases	163.5	753.5	-590.0
Parts for filtering or purifying machinery and apparatus for liquids or gases	189.3	198.5	-9.2
Gas or smoke analysis apparatus	56.8	32.1	24.7
Total	**539.7**	**1 183.7**	**-644.0**

Note:
1. Net exports equals total exports minus total imports and represents the trade balance for the commodity.
Source:
Statistics Canada, International Trade Division.

1. For 1995, data for imports and exports of environmental services were not available.
2. Statistics Canada, 1999, *The Environment Industry: Business Sector, 1996 and 1997, Catalogue No.*16F0008XIE, Ottawa.
3. Delphi Group, 1997, *A Market Analysis of National Funding of Environmental Technology Demonstration and Export Promotion*, Ottawa.

7.4 Environmental practices

To reduce the impacts of their activities on the environment, governments legislate mandatory actions or standards to protect the environment, while business and industry conduct research and development (R&D) on environmental and energy technologies (Figure 7.4.1).

Governments have adopted a number of environmental practices that influence household and business behaviour. These include recycling programs, taxes on scrap tires, and protocols for reducing packaging. As the result of mandatory and voluntary initiatives, or through R&D efforts, industry has also adopted a number of environmental (or cleaner) practices and technologies.

7.4.1 Mandatory environmental actions

Mandatory environmental actions are legal requirements set by governments (see section 7.1–**Environmental legislation and non-regulatory initiatives**). They can take the form of emission controls, performance standards or reporting requirements. For example, mandatory environmental actions include air emission standards on automobiles, sulphur limits in gasoline, emission reporting to the National Pollutant Release Inventory (NPRI), and the Saint Laurent Vision 2000 program.

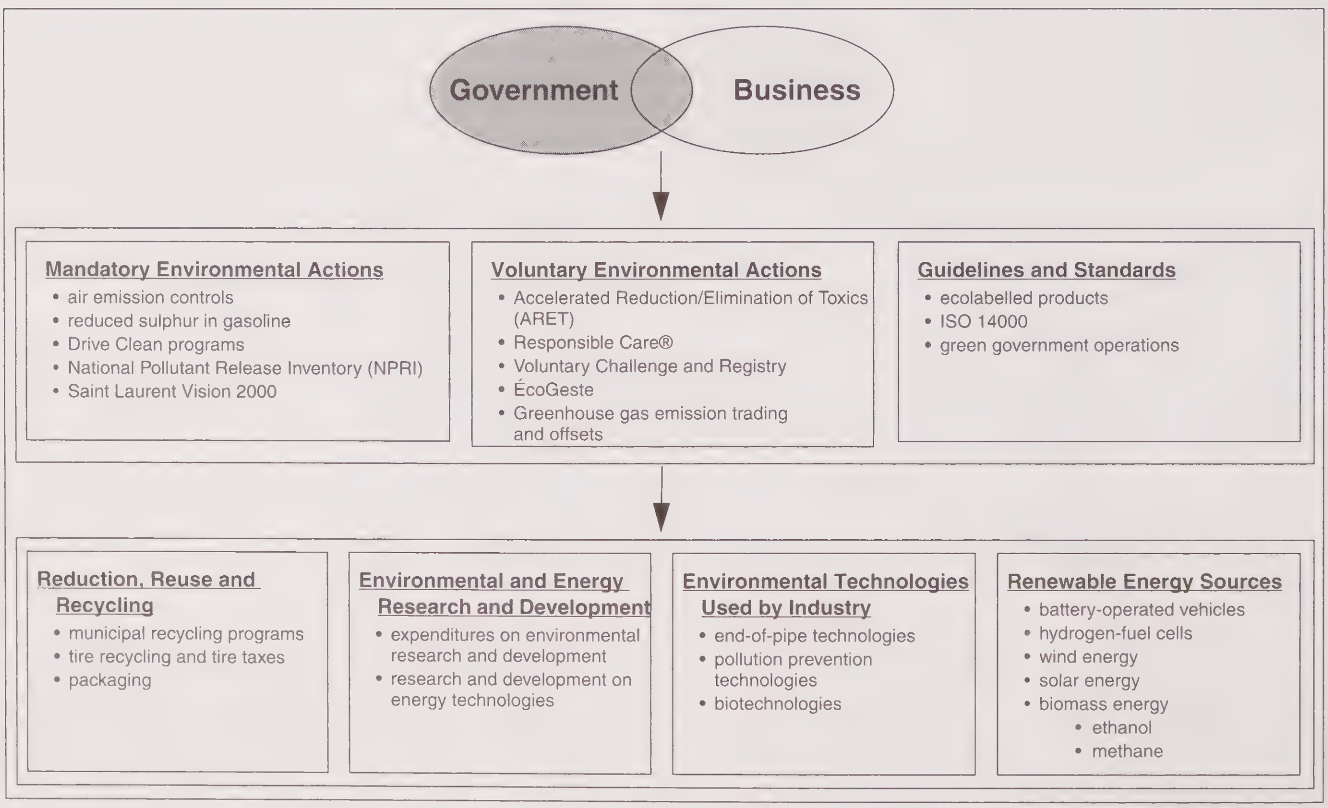
Automobile air emission controls

Motor vehicles are one of the leading causes of pollution, contributing to climate change[1] and ground-level air pollution (see section 6.2–**Air quality**). Transport Canada sets emission standards for new vehicles, and Canada's new vehicle emission standards are fully harmonized with those in the United States under the Environmental Protection Agency's federal emission control program.

For light-duty gasoline vehicles, important improvements in carbon monoxide and total hydrocarbon standards were legislated between 1975 and 1987. With the exception of nitrous oxides, only minor changes have occurred since 1987. In September 1997, non-methane hydrocarbons and particulate matter were regulated for the first time (Table 7.4.1).

1. Emissions of carbon dioxide (CO_2) cannot be controlled by end-of-pipe technologies such as catalytic converters. CO_2 can be reduced only by burning less fossil fuel or by converting to fossil fuels with a lower carbon content.

Figure 7.4.1
Environmental Practices: How Business and Government Interact



Text Box 7.4.1
Light Trucks with Less Stringent Air Pollution Regulations

A phenomenon that is common to Canada and the United States is the increasing appeal to consumers of larger, multipurpose minivans and sport-utility vehicles. These vehicles have a lower average fuel economy than automobiles since they are not subject to the same stringent regulations as passenger cars. "Over the past 20 years, light trucks have doubled their market share of light-duty vehicle sales in the United States. Trucks captured 30% of the American light-duty market in 1990, 36% in 1993 and 39% in 1995. It appears that a similar trend is occurring in Canada, with a commensurate increase in emissions."[1, 2]

1. Environment Canada,1997, *Trends in Canada's Greenhouse Gas Emissions 1990—1995*, p. 27, Ottawa.
2. Bamberger, Robert, 1998, *Automobile and Light Truck Fuel Economy: Is CAFE up to Standards*? The Committee for the National Institute for the Environment, <http:/www.cnie.org/nle/air-10.html>, (accessed October 10, 1998).

Table 7.4.1
Light-duty New Vehicle Gasoline Exhaust Emission Standards, 1975-1997

Pollutant	1975	1987	1997
	grams per kilometre		
Total hydrocarbons	1.20	0.25	0.25
Non-methane hydrocarbons	...	...	0.16
Carbon monoxide	16.00	2.10	2.10
Nitrous oxides	1.93	0.62	0.25
Particulate matter	...	...	0.05

Source:
Environment Canada, *Emissions Standards for Motor Vehicles*, <http://www.ec.gc.ca/emission/4-1e.html>, (accessed October 12, 1998).

The new regulations include tougher emission controls for most pollutants. They also require that light-duty vehicles be equipped with on-board diagnostic systems that monitor vehicle emissions. However, popular sport-utility vehicles are excluded from these tighter emission controls (Text Box 7.4.1).

Lowering sulphur levels in gasoline

Another significant motor-vehicle emission is the sulphur in gasoline. Sulphur is not only harmful to the environment and to human health (see section 6.6–**Human health** and Text Box 7.4.2), but it also has an adverse effect on vehicle emission control systems. This results in an increase in other motor vehicle pollutants such as carbon monoxide, nitrogen oxide, volatile organic compounds, sulphur dioxide, sulphate particulates and benzene.[1]

1. Environment Canada, 1998, *Final Report of the Government Working Group on Sulphur in Gasoline and Diesel Fuel*, <http://www.ec.gc.ca/oged-dpge/level3e/FinalSulphurReport/execsume.htm>, (accessed July 14, 1998).

Text Box 7.4.2
Health Benefits of Reducing Sulphur in Gasoline

It has been estimated that with the introduction of low-sulphur gasoline, the following will be prevented over a 20-year period:

- over 2 100 premature deaths;
- 93 000 incidences of bronchitis in children;
- 5 million other health-related incidents such as asthma attacks; and
- 11 million acute respiratory symptoms such as colds, pneumonia and croup.

Source:
Environment Canada, 1998, Low Sulphur Gasoline, <http://www.ec.gc.ca/press/sulphur_b_e.htm>, (accessed September 16, 1999).

In 1998, the average sulphur level in Canadian gasoline was 350 parts per million (ppm)—among the highest of all industrialized countries. In comparison, the average sulphur content was 30 ppm in Japan and California, 310 ppm in the United States, and 340 ppm in Great Britain. The European Union has recently set a requirement of 150 ppm by the year 2000 and 50 ppm by 2005.

In 1999, new regulations under the *Canadian Environmental Protection Act* (CEPA) set a limit of 30 ppm of sulphur content in gasoline by the year 2005—a reduction of more than 90% from current levels.

Estimates suggest that the cost to petroleum refiners of reducing the sulphur content of gasoline to 30 ppm in Canada would be $1.8 billion in capital expenditures and $119 million per year in operating expenditures. This would result in an increase of one cent per litre in the price of gasoline or approximately $20 per year per car for the average motorist. Refinery technology suppliers have recently developed new lower-cost sulphur-reducing technologies. Several new units are expected to be in operation in early 2000 and will cost up to 50% less to operate than the current technologies.[2]

Drive Clean programs

Several provincial governments have introduced Drive Clean programs that require mandatory testing of vehicle tailpipe emissions in order to reduce smog-causing pollutants from passenger cars, trucks and buses. Vehicles failing the test must be repaired and retested.

In British Columbia, the AirCare Program tests emissions from all light-duty vehicles registered in the Lower Mainland and the Lower Fraser Valley. Between September 1992 and August 1997, AirCare conducted 4.9 million tests on 1.5 million vehicles—of these, 0.4 million vehicles failed the test

2. Environment Canada, 1998, *Low Sulphur Gasoline*, <http://www.ec.gc.ca/press/sulphur_b_e.htm>, (accessed September 16, 1999).

Text Box 7.4.3
Reductions of Smog-Causing Emissions in Ontario

The overall goal of Ontario's Smog Plan is to reduce emissions of NO_x and VOCs by 45% from 1990 levels by 2015. This will require reductions from steel plants and other stationary industrial sources.

With increased use of natural gas in light- and heavy-duty cars and trucks, it is expected that NO_x emissions will be reduced by some 900 tonnes and VOCs by 800 tonnes by 2015. Conversion to propane as an automotive fuel will also produce further reductions of 5 100 tonnes of NO_x and 2 400 tonnes of VOCs by 2015.

at least once (Table 7.4.2).[1] As a result of the program, total vehicle emissions have dropped by half from 1993 levels. The AirCare program estimates that repairs save drivers 5% or $72 per year in fuel costs.

The Ontario Drive Clean program, implemented in April 1999, requires older vehicles (model years 1980 to 1995) to undergo emission testing. The program, which currently operates in the Greater Toronto Area and the Hamilton–Wentworth region, will be extended to an additional 13 urban areas by 2001.[2]

When Drive Clean is fully implemented in the year 2002, the province of Ontario anticipates that smog-causing pollutants will be reduced by 22% in the program areas. This translates into reductions of 15 000 tonnes of NO_x, 47 000 tonnes of VOCs and 900 kilotonnes of CO_2. Further reductions in smog-causing emissions are also expected as a result of Ontario's Smog Plan (Text Box 7.4.3).

Table 7.4.2
British Columbia's AirCare Program, 1993-1997

Year	Total inspections	Number of vehicles	Number of failed vehicles
1993	743 506	549 637	126 894
1994	1 182 294	1 010 356	132 113
1995	1 125 309	1 002 566	104 373
1996	631 504	550 868	79 841
1997	1 235 551	1 060 344	143 499

Source:
British Columbia AirCare Program, *AirCare by the Numbers*, <http://www.aircare.ca>, (accessed June 10, 1999).

1. British Columbia AirCare Program, 1999, *It's the air we breathe*, <www.aircare.ca>, (accessed June 10, 1999).
2. Ontario Ministry of the Environment, 1998, *Drive Clean Update*, <www.driveclean.com>, (accessed June 10, 1999).

Text Box 7.4.4
Reporting Requirements of the National Pollutant Release Inventory (NPRI)

The NPRI is mandatory, and a total of 176 substances have been identified for reporting in the NPRI.[1] Facilities must report on-site releases of pollutants to air, water and land, as well as transfers of waste and material for recovery, reuse and recycling off-site, and for energy recovery.

Any facility that has 10 or more full-time employees and that manufactures, processes or otherwise uses any of the specified NPRI substances may be subject to reporting.[2] The NPRI does not cover the following: farms (many of which use chemical fertilizers and pesticides); small businesses (such as dry cleaners and service stations); and mobile sources of emissions (such as cars and trucks).

In 1996, 1 818 facilities reported to the NPRI. Almost half of these facilities were located in Ontario (49%), while Quebec (22%) and Alberta (11%) made up another third.

1. The government announced on April 29, 1999 that facilities are required to report on 73 more pollutants, including 20 toxic substances, starting in the 1999 reporting year. Included are ozone-depleting substances. The government plans to expand the NPRI pollutant list again in 2000, as well as lower the thresholds for reporting certain substances.
2. These are facilities that used any of the NPRI-listed substances, in concentrations equal to or greater than 1% by weight and in quantities equal to or greater than 10 tonnes.

National Pollutant Release Inventory (NPRI)

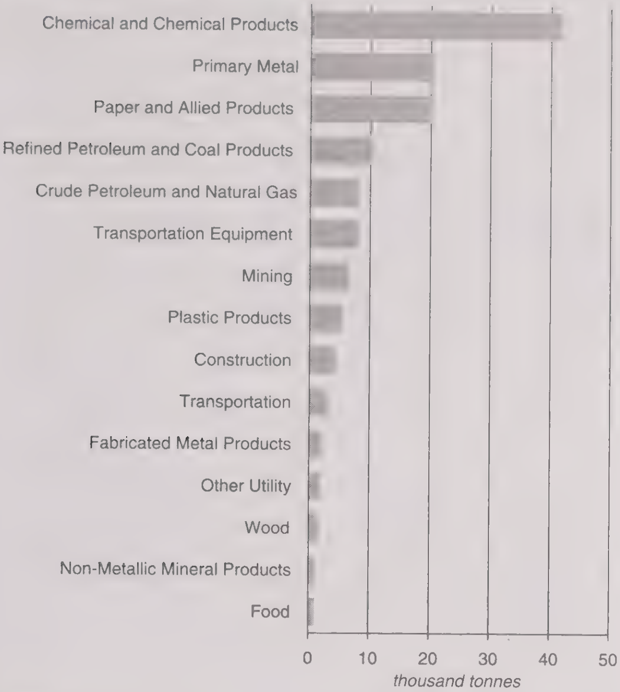
The National Pollutant Release Inventory (NPRI) is a nationally legislated inventory of pollutant releases and transfers in Canada. The NPRI was created in 1992 under the *Canadian Environmental Protection Act* (CEPA) to provide Canadians with a publicly accessible database on pollutant releases. Any facility that meets the reporting requirements of the NPRI must file a report with Environment Canada (Text Box 7.4.4).

Figure 7.4.2 shows the amount of on-site pollutants released by various industrial sectors in 1996. The top three emitters were the Chemical and Chemical Products, Primary Metal, and Paper and Allied Products industries.

Saint Laurent Vision 2000

The federal and Quebec governments and industry have been working together since 1988 to safeguard the St. Lawrence River. The St. Lawrence Action Plan, created in 1989, was renamed Saint Laurent Vision 2000 (SLV 2000) in 1994. The goal of SLV 2000 is to conserve and protect the St. Lawrence River ecosystem.

Figure 7.4.2
Release of On-site NPRI Pollutants by Industry, 1996



Source:
Environment Canada, 1998, *National Pollution Release Inventory, Summary Report 1996*, <http://www.ec.gc.ca/pdb/npri/1996/page6.html>, (accessed May 3, 1999).

The environmental protection component of SLV 2000 is aimed at reducing toxic effluent discharges and eliminating discharges of 11 persistent toxic substances from 106 industrial plants located along the St. Lawrence River.

From 1988 to 1995, 50 plants implemented clean-up measures and invested $650 million in modifications to their industrial processes. The result was a 92% reduction in suspended solids and a 96% drop in biochemical oxygen demand (see section 6.1–**Waste generation and management**). The goal of reducing toxic discharges by 90% was surpassed and the rate of liquid toxic discharges declined by 96% at the targeted plants.[1]

7.4.2 Voluntary environmental actions

In order to move towards better environmental practices and sustainable development, industry and governments have opted to participate in voluntary programs. An alternative to environmental regulations and mandatory programs,[2] voluntary actions include codes of environmental practice, guidelines, emission and waste reduction targets, as well as agreements with governments.

1. Saint Laurent Vision 2000, 1996, *La réduction des rejets liquides toxiques des 50 établissements industriels prioritaires du plan d'action Saint Laurent*, Rapport synthèse, 1988–1995, Montréal.

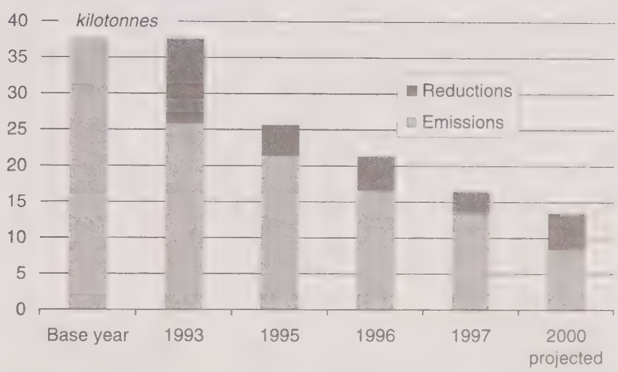
Accelerated Reduction/Elimination of Toxics (ARET)

In force since 1994, ARET is the most important voluntary initiative in place to reduce the release of toxic substances. ARET targets 117 toxic substances that pollute the environment and pose a health risk to society and requires participants to submit action plans detailing their reduction goals and strategies.

Both industry and government organizations participate in this program: as of 1997, 303 facilities from 162 companies and government organizations were participating. An additional 128 companies reporting negligible or no emissions have filed declarations of support for ARET.

ARET's objective is to reduce persistent, bioaccumulative and toxic substances by 90% and to cut all other toxic substance emissions by 50% by the year 2000. Over the long term, ARET's goal is to eliminate emissions of 30 persistent, bioaccumulative and toxic substances and to reduce 87 other toxic substances to levels not considered harmful. Results up to 1997 show that ARET participants reduced emissions by 24 090 tonnes, a decrease of 64% from base-year levels.[3] ARET projected a further reduction of 5 172 tonnes by the year 2000 (Figure 7.4.3). The chemical manufacturing, mining and smelting, and pulp and paper industries have had the largest percentage reduction in emission levels from base year to 1997 (Table 7.4.3).

Figure 7.4.3
ARET Emission Reductions,[1] Base Year to 2000



Note:
1. Companies that take part in the ARET program were given the option of using any base year from 1988 to 1992 for comparison purposes.
Source:
Environment Canada, Accelerated Reduction/Elimination of Toxics program, 1999, *Environmental Leaders 3: Voluntary Action on Toxic Substances (May 1999)*, <http://www.ec.gc.ca/aret/reports.html>, (accessed May 15, 1999).

2. A number of these voluntary actions were recently reviewed by the Commissioner of the Environment and Sustainable Development in the latest report to the House of Commons. The report is available at <http://www.oag-bvg.gc.ca/domino/reports.nsf/html/c9menu_e.html>, (accessed October 22, 1999). (See Chapter 4–Managing the Risks of Toxic Substances.)
3. Companies have the option of using any base year from 1988 to 1992 for comparisons.

Table 7.4.3
Emission Reduction by Industry Group, Base Year[1] to 1997

Sector	Reduction in emissions	
	percent	tonnes
Aluminum	53	473
Chemical manufacturing	76	1 957
Chemical specialities manufacturing	25	104
Electric	46	54
Government	..	..
Other manufacturing[2]	36	275
Mining and smelting	71	5 545
Oil, gas and petroleum products	52	863
Pulp and paper	69	13 557
Steel	35	1 457

Notes:
1. Companies that take part in the ARET program were given the option of using any base year from 1988 to 1992 for comparison purposes.
2. This industry group includes companies that do not fall under any other sectors participating in ARET.

Source:
Environment Canada, Accelerated Reduction/Elimination of Toxics program, 1999, *Environmental Leaders 3: Voluntary Action on Toxic Substances (May 1999)*, <http://www/ec/gc/ca/aret/reports.html>, (accessed May 15, 1999).

Responsible Care

Responsible Care targets emissions of chemicals, greenhouse gases (GHGs), ozone-depleting substances and heavy metals.[1] Created by the Canadian Chemical Producers' Association (CCPA) in 1985 in response to public concerns regarding the safe and environmentally sound management of chemicals, this program has since grown to become a global initiative that includes chemical industry associations in more than 40 countries covering over 80% of the world's chemical products.

CCPA member companies produce over 90% of the industrial chemicals in Canada.[2] In 1997, CCPA member companies released 276 substances, or mixtures, into the environment but reduced their overall emissions[3] by 55% between 1992 and 1997 (Table 7.4.4).[4]

CCPA member companies decreased their emissions of VOCs and NO_x, the principal causes of ground level ozone, by 22% between 1992 and 1996. Carbon dioxide emissions increased 6% between 1992 and 1997, while methane emissions increased 35% above 1992 baseline levels.

Emissions of ozone-depleting substances from CCPA members were 63% lower in 1997 compared with 1992 levels (see section 2.3–**Stratospheric ozone depletion**). Release of heavy metals to water has been reduced from 210 tonnes in 1992 to 40 tonnes in 1997.

1. The Responsible Care® reporting list contains 500 substances that have been assessed as toxic. Many of these are also found on the NPRI and ARET lists, as well as on the *Canadian Environmental Protection Act* Schedule 1 substance list and on the Priority Substance List.
2. Canadian Chemical Producers' Association, *Responsible Care® 1997, Good Neighbours, Good Sense,* <http://www.ccpa.ca/Reports/1998/RC97/index.html>, (accessed July 22, 1999).
3. Includes all substances emitted by CCPA member companies with the exception of carbon dioxide.
4. Canadian Chemical Producers' Association, *Reducing Emissions 6: 1997 Emissions Inventory and Five-Year Projections,* <http://www.ccpa.ca/Reports/1998/NERM97_Eng.pdf>, (accessed July 22, 1999).

Table 7.4.4
Emissions of Canadian Chemical Producers,[1,2] 1992 and 1997

	1992	1997	Change
	tonnes		percent
Air	128 000	112 600	-12
Water	138 000	640	-100
Underground injection	2 700	7 800	189
Land	1 800	240	-87
Canada	**270 000**	**121 300**	**-55**

Notes:
Figures may not add up to totals due to rounding.
1.Emissions are from CCPA members only and do not represent total chemical emissions.
2.Excludes carbon dioxide emissions.

Source:
Canadian Chemical Producer's Association, *Reducing Emissions 6: 1997 Emissions Inventory and Five-Year Projections.* <http://www.ccpa.ca/Reports/1998/NERM97_Eng.pdf>, (accessed July 22, 1999).

Voluntary actions and climate change

Climate change is an increasingly important environmental issue. In December 1997, Canada and more than 150 countries reached an agreement that sets limits on greenhouse gas emissions from industrialized countries (see section 2.2–**Climate change**). Canada's target is to achieve a reduction of 6% below 1990 levels by 2012. Canadian governments, industry and environmental groups are examining options to reduce GHG emissions.

The federal government's Climate Change Secretariat has identified 37 voluntary initiatives relating to GHG emissions in Canada.[5]

The Voluntary Challenge and Registry and ÉcoGeste (and in part Responsible Care) represent examples of reporting programs related to GHG emission reductions, while GHG emissions trading and offsets are examples of actual market or tools for such reductions.

Voluntary Challenge and Registry (VCR)

The VCR program was established by Natural Resources Canada in late 1994 as part of the National Action Program on Climate Change. In 1997, VCR became an independent non-profit corporation[6] that addresses the issue of climate change by encouraging companies and organizations to voluntarily reduce greenhouse gas emissions.

As part of their membership in the VCR program, participants are asked to set voluntary goals for the reduction of GHG emissions and to report the results against a base year, 1990. These targets are to be set in line with the Kyoto targets for GHG emission reductions for the period 2008 to 2012 (see section 6.2–**Air quality**).

5. For an inventory of voluntary initiatives related to GHG emissions, see Climate Change Secretariat, Enhanced Voluntary Action Issue Table, 1998, *Foundation Paper*, Ottawa.
6. The National Action Program on Climate Change was developed in 1990 by federal, provincial and territorial energy and environment ministers and their officials. The NAPCC sets out principles, strategic directions and opportunities for the reduction of greenhouse gas emissions.

Table 7.4.5
Voluntary Challenge and Registry Program Progress, 1995-1998

Year	Registrants	Action plans	Progress reports
1995	475	94	4
1996	619	331	88
1997	701	354	112
1998	874	547	168

Source:
Voluntary Challenge and Registry Inc., *Annual Report*. <http://www.vcr-mvr.ca>, (accessed May 5, 1999).

Participation in the VCR program has been increasing steadily since its inception. As of December 1998, 874 companies and organizations had registered. More than half of those registering in the program have devised action plans while around 20% have submitted progress reports (Table 7.4.5).

ÉcoGeste

ÉcoGeste is a voluntary registration program established by the Quebec provincial government as part of a plan of action on climate change (much like the VCR). ÉcoGeste began in 1996 as a voluntary program to reduce carbon dioxide emissions in Quebec to 1990 levels by the year 2000.

As of 1997, 70 organizations were registered with ÉcoGeste. Also added to this total are another 72 Quebec organizations that are registered with VCR. Results from ÉcoGeste indicate that there was a reduction of 7 megatonnes of greenhouse gases over the period 1990 to 1998.[1]

Greenhouse gas emission trading and offsets

In addition to voluntary programs to reduce GHG emissions, GHG emission trading and GHG offset opportunities are actual methods that businesses use to reduce these emissions.

Emission trading

Emission trading of GHG is a mechanism through which one firm pays another to reduce GHG emissions on its behalf (Text Box 7.4.5). The company that pays earns a 'credit' for the reduction.

Voluntary pilot emission trading systems have emerged as a way of reducing GHG emissions in the absence of regulated caps (Text Box 7.4.6). In Canada, there are the Pilot Emission Reduction Trading (PERT) program and the Greenhouse Gas Emission Reduction Trading (GERT) pilot program. Emission trading programs enable businesses to reduce air emissions sooner than regulations require.

Through PERT, Canadian businesses can earn credits from early reductions by adopting environmental technologies that reduce GHG and other air emissions. These credits can be banked for future use or sale (trades) to support voluntary agreements or in anticipation of new government regulations.

Since 1996, industry has been operating the PERT project. The goal of the project is to look at emission trading systems to reduce certain pollutants (e.g., NO_x, SO_2 and CO_2) being released in the Windsor–Quebec corridor. To date, there have been a small number of trades. Ontario Hydro is PERT's most active participant, with six emission reduction credits and trades.[2]

GERT was launched in June 1998 to allow government, industry and other sectors to use the trading process for GHG emissions. British Columbia spearheaded the GERT program where B.C. Hydro registers emission offsets. Partners include provincial governments from British Columbia, Alberta, Saskatchewan and Nova Scotia, the federal departments Environment Canada and Natural Resources Canada, a number of industry associations, two environmental groups and labour unions. Traded emission reductions are registered with the VCR and will be used for credit against future reduction obligations. To date, six offers to sell emission reductions and three trades have been submitted to GERT.[3]

Text Box 7.4.5
What is Emission Trading?

Emission trading is an arrangement or system whereby one company or organization pays another to reduce greenhouse gas emissions on its behalf. Because of the global impact of climate change, these actions provide a net benefit to the atmosphere.

Climate change requires global solutions. Companies in Canada are looking outside their operations at opportunities that contribute to fewer greenhouse gases. Companies can offset their greenhouse gas emissions by emission reduction trading and forest conservation in other parts of the world.

Under an emission reduction trading system, a company can pay another company to reduce greenhouse gases on its behalf. The company making the reduction passes ownership of these reductions to the purchaser, who uses the reduction to offset or 'write off' some of its own greenhouse gas emissions. Trading arrangements allow companies to obtain 'credits' for reducing greenhouse gas emissions. By placing a value on greenhouse gas reductions, it can also further stimulate industry to develop and use more eco-efficient technologies.

1. Climate Change Secretariat, 1998, *Foundation Paper*, prepared for Enhanced Voluntary Action Issue Table, by The Conference Board of Canada and Paul Griss, November, 1998, Ottawa.
2. Pilot Emission Reduction Trading Project (PERT), <http://www.pert.org> and <http://www.airregistry.com>, (accessed May 15, 1999).
3. Greenhouse Gas Emission Reduction Trading Pilot Program (GERT), <http://www.gert.org>, (accessed June 1, 1999).

Text Box 7.4.6
Examples of Emission Trades

Ontario Hydro

Utilities in the United Sates are negotiating to purchase credits from Ontario Hydro's low-NO_x combustion technologies at Lambton and Nanticoke generating stations.

In 1998, Ontario Hydro purchased 10 000 tonnes of CO_2-reduction credits from Southern California Edison for $30 000 US. These credits were the result of energy efficiency improvements at the Mohave Power Plant in Nevada.

In 1998, Ontario Hydro agreed to purchase 35 tonnes of NO_x emission reduction credits created by the use of fuel additives developed by the Shell Chemical Company.[1] This fuel additive helps reduce NO_x and volatile organic compounds (VOCs) from cars. Ontario Hydro paid about $55,000 for the credits—the fifth credit transaction by the electric utility.

Suncor Energy Inc.

In 1998, Suncor Energy Inc. purchased 100 000 tonnes of greenhouse gas emission reduction from the U.S.-based Mohawk Power Corp. This deal was one of the world's first international emission reduction trades.[2] The reduction will be made as Niagara Mohawk switches from coal- to natural gas-generated electricity, takes on renewable energy projects, and promotes more efficient use of energy by its customers. The reductions are measured by the Environmental Resources Trust to ensure that there is a net benefit to the atmosphere.

1. Ontario Hydro, 1998, *Ontario Hydro Emission Reduction Credit Purchase, A Boon to the Environment*, July 29, News release.
2. Suncor Energy, 1998, "Suncor Energy and Niagara Mohawk Make International Greenhouse Gas Emission Reduction Trade," <http://www.suncor.com/04news/04frame1.html>, (accessed May 10, 1999).

Emission offsets

An offset is another management tool that compensates for increased emissions from one source by reducing emissions from another source, without actually trading credits for the reduction with another company. Greenhouse gas offset projects include a number of activities (Text Box 7.4.7):

- control and capture of GHG;
- technology and process changes in energy production;
- technology, process and behavioural changes in energy use;
- fuel substitution that reduces the use of carbon-based fuels;
- preservation of natural carbon sinks;[1] and
- carbon sequestration[2] through land use changes.

7.4.3 Guidelines and standards

Ecolabelled products

Consumers[3] are now beginning to demand environmentally friendly products. 'Ecolabels' inform consumers about product characteristics that may not be obvious and can help consumers choose products that minimize environmental impacts.[4]

The Environmental Choice Program (ECP) is the Canadian program responsible for administrating ecolabels under the EcoLogo label. Consumers and industry have responded positively to the program. In a 1996 survey, one in five Canadians said that they or someone in their household had purchased a product carrying the EcoLogo label.[5]

In general, manufacturers request a label for a particular product. As of 1999, about 2 000 products and services from 180 companies were carrying the EcoLogo label.[6] To earn the EcoLogo symbol, a product or service must

- improve energy efficiency;
- reduce hazardous waste by-products;
- use recycled materials;
- be reusable; or
- provide some other environmental benefit.[7]

Currently, there are 48 guidelines for a variety of products and services, ranging from recycled plastic products to rechargeable consumer batteries. Take, for example, the ECP guideline for diapers. Approximately 1.7 billion disposable diapers are used each year in Canada, accounting for about 85% of the diaper market. While there continues to be some debate about which type of diaper—

1. A carbon sink is an area where the rate of carbon absorption by living organisms exceeds the rate of carbon release, so that carbon is actively sequestered in organic or inorganic forms.
2. Carbon sequestration is increasing the amount of carbon stored in the soil and in forests. This process helps to slow the trend toward increasing concentrations of carbon dioxide in the atmosphere.
3. The term 'consumer' is not just limited to private citizens and households but includes governments, large institutions and businesses wishing to incorporate environmental considerations in purchasing decisions.
4. United States Environmental Protection Agency, 1996, *Environmental Labelling Issues, Policies and Practices Worldwide.* <http://www.epa.gov/oppintr/environmental-labeling>, (accessed May 27, 1999).
5. *Ibid.*
6. For a complete list of EcoLogo[M] products and services, see <http://www.interchg.ubc.ca/ecolabel/canguide.htm>, (accessed May 27, 1999).
7. TerraChoice Environmental Services Inc., <http://www.terrachoice.ca/ecologo.htm>, (accessed April 28, 1999).

Text Box 7.4.7
Examples of Emissions Offsets

B.C. Hydro

B.C. Hydro sells and buys electric power to and from Alberta and sells surplus power to U.S. markets. Because of the ways it generates electricity, B.C. Hydro is a net exporter of lower levels of GHG emissions into areas of higher GHG intensity. For example, GHG emission reductions could occur if B.C. Hydro's power exports displaced coal-fired generation produced elsewhere.

B.C. Hydro currently purchases electricity from two wood residue (biomass) power plants. Electricity generated from wood residue is assumed to be GHG-neutral (i.e., no net GHG emissions are released to the atmosphere).

Another way to offset GHG emissions is to promote more energy-efficient technologies in other countries. In 1998, B.C. Hydro International and Brazil's energy efficiency program entered into a three-year agreement in which B.C. Hydro International would transfer energy-efficient technologies to Brazil. This transfer is expected to reduce the need to build new plants in Brazil, potentially reducing GHG.

SaskPower

Fly ash from coal-powered electric generators is used as a substitute for cement in the production of concrete. Since the production of cement is very energy intensive, the use of fly ash leads to a reduction of GHG emissions.

The 36 000 tonnes of fly ash sold by SaskPower in 1996 had the potential to reduce CO_2 emissions by 18 000 tonnes. By 2000, sales are projected to increase to 61 000 tonnes per year, reducing emissions of CO_2 by 30 500 tonnes.

Suncor Energy Inc.

In Belize, Suncor Energy Inc. is involved in protecting 19 000 acres of forestland from being burned and converted into farmland. Keeping this forest area intact prevents some 400 000 tonnes of CO_2 from being released into the atmosphere. The forests continue to sequester CO_2 in addition to protecting this habitat.

Sources:
BC Hydro, Environment, 1998, *Progress Report on Greenhouse Emissions*, <http:// www.bchydro.bc.ca/environment>, (accessed on May 14, 1999).
SaskPower, 1996, *Climate Change Report*. <http://www.saskpower.com>, (accessed May 5, 1999).

disposable or cloth—has a greater impact on the environment, cloth diapers currently carry the EcoLogo environmental label in Canada.

Another familiar ecolabel in Canada is the EnerGuide label administered by the Office of Energy Efficiency at Natural Resources Canada. The EnerGuide label helps consumers make energy-wise choices when buying new appliances. The label shows how much energy appliances consume in a year of normal use and makes it easy to compare the energy efficiency of different models. Major electrical household appliances and room air conditioners sold in Canada must meet minimum energy efficiency standards and are required to have the EnerGuide label.[1]

ISO 14000

Another set of environmental guidelines used by companies in Canada and throughout the world is the ISO 14000 series developed by the International Organization for Standardization (ISO).[2] These guidelines are an environmental management system based on three sets of tools: life-cycle analysis of products and services,[3] environmental performance evaluation, and environmental labelling of products and services. Using the ISO 14000 guidelines may bring a number of benefits, from waste minimization to energy savings, while offsetting the costs of reducing environmental impacts.

Over the past 10 years, the ISO 9000 series[4] has been widely accepted in Canada. The number of certifications jumped from 292 in 1993 to 5 852 by the end of 1997.[5]

Although ISO 14000 has only been in existence since 1997, it is anticipated that it will overtake the ISO 9000 series. In 1999 ISO 14000 certificates worldwide numbered 9 455—Japan led with 1 960 registered firms, the United States ranked 7th with 400, and Canada ranked 19th with 85 companies certified as of December 1998 (Table 7.4.6).[6]

Green government operations

While the main objective of 'greening' operations is to reduce environmental impacts, governments may obtain large financial and environmental benefits from behaving in a more sustainable manner.

1. Natural Resources Canada, Office of Energy Efficiency, 1999, <http:// www.oee.nrcan.gc.ca>, (accessed October 22, 1999).
2. Standards Council of Canada, 1998, <http://www.scc.ca/iso14000>, (accessed December 15, 1998).
3. Life-cycle analysis (LCA) is a tool used to identify and measure direct and indirect environmental, energy and resource impacts associated with a product, process or service. LCA is a method of checking the facts about the environmental burden of a product from its design through to production and final disposal. (International Institute for Sustainable Development, 1996, *Global Green Standards, ISO 14000 and Sustainable Development*, Winnipeg).
4. ISO 9000 is a set of guidelines primarily concerned with quality management and the production of goods and services that meet customers' requirements. ISO 14000 is concerned with environmental management—the elimination of the harmful effects on the environment caused by businesses' activities.
5. International Organization of Standards, *The ISO Survey of ISO 9000 and ISO 14000 Certificates, Seventh Cycle, 1997*, <http://www.isoeasy.org/ iso7.pdf>, (accessed May, 25, 1999).
6. As of March 31, 1999, 100 businesses were certified in Canada—a growth rate of 18% since December 1998. (*Welcome to ISO World*, <http:// www.ecology.or.jp/isoworld/english/iso_14k.htm>, accessed December 8, 1998 and May 5, 1999).

Table 7.4.6
Canadian Registrations to ISO 14000, December 1998

Industry	Number of companies	Number of sites
Automotive	3	6
Chemical producers	8	17
Manufacturing	20	32
Pulp and paper	9	20
Primary metals	1	1
Utilities	2	2
Transport	1	1
Government	2	3
Other	3	3
Total	**49**	**85**

Source:
Environment Canada, <www.ec.gc.ca/ems%2Dsme/download/isocompe.pdf>, (accessed April 28, 1999).

Table 7.4.7
Selected Municipal and Provincial Data on Recycling, 1997 and 1998

	Recycling program	
Material type	Ontario blue box program, 1997	City of Winnipeg, 1998
	tonnes	
Paper	429 000	16 621
Glass	102 000	3 103
Metals	44 000	1 638
Plastic	27 000	992
Other	..	2 615
Total	**595 000**	**24 969**

Sources:
Ontario Ministry of the Environment, 1998, *Municipal 3Rs in Ontario: 1997 Fact Sheet*, Toronto.
The City of Winnipeg, Water and Waste Department, Solid Waste Division, 1999, City of Winnipeg Recycling Programs, *Summary of Materials, 1998: Solid Waste Diverted from Waste Stream,* Winnipeg.

The federal government is the largest business in Canada. While many aspects of government operations have the potential to affect the environment, there are numerous opportunities to reduce adverse impacts while cutting costs. For example, the federal government annually spends

- $11.6 billion on goods and services;
- $800 million on energy in its buildings;
- $100 million on water supply and disposal;
- $21 million in fuel for its 25 000 vehicles; and
- $6.5 million on disposal of 95 000 tonnes of office waste.[1]

The Commissioner of the Environment and Sustainable Development has estimated that the federal government could save between $60 million and $120 million per year on energy use by retrofitting heating, cooling and lighting systems in its buildings.

Also, the federal government can purchase environmentally preferable products and services that have a lower environmental impact during production, use and disposal. For example, Canada Mortgage and Housing Corporation (CMHC) initiated a green procurement program that has yielded savings of $60 000 per year: of the 500 office products CMHC purchases annually, more than 100 are environmentally friendly.[2]

7.4.4 Reduction, reuse and recycling

Both governments and industry have introduced a number of initiatives to reduce, reuse and recycle the waste produced by consumers. Municipal governments have led the way with recycling programs; provincial governments have regulated the recycling and reuse of scrap tires; and the federal and provincial governments have developed a protocol to reduce the amount of packaging.

Municipal recycling programs

Since the early 1980s, blue boxes have become a common sight on residential curbsides across Canada. The blue box system of residential recycling was adopted by many provincial and local jurisdictions to próvide a simple means for residents to divert certain recyclable materials from landfills and incinerators. The most common materials recycled using the blue box are newsprint, glass and various types of plastic (see section 6.1–**Waste generation and management**).

Many provinces do not have comprehensive tracking systems that can adequately assess blue-box diversion rates.[3] Data on blue-box diversion quantities are often available only at the municipal level and rarely by province (Table 7.4.7).

Innovative variations on the traditional blue box system are being used for other recyclable material. In Newfoundland, a provincial agency operates a number of ‘green depots’ around the province. Nova Scotia and Alberta have deposit–return systems for certain materials. For example, Nova Scotia has more than 90 Enviro-Depots® where over 60 million beverage containers are diverted from provincial landfill sites. The return rate for these deposit–return systems is about 75%.[4]

In 1996, Manitoba launched an integrated product stewardship program that is based on the principle of ‘distributor responsibility.’ The mandate of the program is to maximize the 3Rs (reduce, reuse, recycle), to hold distributors of products responsible for the costs of managing the

1. *1999 Report of the Commissioner of the Environment and Sustainable Development,* Ottawa, <http://www.oag-bvg.gc.ca/domino/reports.nsf/html/c9menu_e.html>, (accessed October 22, 1999).
2. Environment Canada, 1996, *Green Procurement*, <http://www.ec.gc.ca/gog/procure/progress/procure.html>, (accessed May 15, 1999).
3. Diversion rates are the quantities of waste diverted from landfill site through the blue box program.
4. Nova Scotia's Resource Recovery Fund Board Inc., 1997, Deposit–Refund Program. <http://www.rrfb.com>, (accessed June 22, 1999).

waste from these products, and to provide long-term funding for recycling programs in Manitoba.[1]

Innovative integrated processes that expand the traditional materials handled by the blue box system have also been introduced. For example, in 1995 the wet/dry system was established in Guelph, Ontario; this system relies on the generator of the waste materials to separate them into different-coloured bags, one for wet materials and one for dry.

Tire recycling and tire taxes

Across Canada, some 26 million scrap tires a year are stockpiled. Stockpiled tires pose an environmental threat—they are a potential fire hazard and, in landfills where the tires cannot be compacted, they create a methane gas buildup.

Provincial governments have conducted several initiatives to reduce the number of scrap tires going into landfill sites or being stockpiled. Most provinces have a tire tax on the purchase of new tires; this revenue is used to fund scrap tire collection and recycling programs (Table 7.4.8). Scrap tires have a number of uses as recycled materials or as a source of energy (Text Box 7.4.8).

1. Manitoba Stewardship Program, 1997, *Manitoba Stewardship Program, April 1, 1996 to March 31, 1997*, Winnipeg.

Packaging

Most of us rarely think about the packaging of the goods we buy. Yet it is estimated that every year the average Canadian family throws out a tonne of packaging.[2]

The main functions of packaging are to reduce breakage of goods and to prevent spoilage in foods (Text Box 7.4.9). Virtually all manufactured and processed products require packaging during some phase of their production or distribution. Consumed (used) packaging may be reused in its current form, recycled, composted or discarded.

Increased packaging has created a solid-waste disposal problem. In 1990, the Canadian Council of Ministers of the Environment (CCME) and industry established the National Packaging Protocol, a commitment to reduce the amount of packaging going into landfills by 50% (from 1988 levels) by the year 2000.[3]

Approximately 2.6 million tonnes of packaging was sent for disposal in 1996, compared with 5.4 million tonnes in 1988 (Figure 7.4.4 and Table 7.4.9). This represents a 51% reduction and exceeds the National Packaging Protocol milestone target of 35% by 1996 and 50% by 2000. Half of these diversions were achieved through the use of less packaging material as well as reuse initiatives.

2. Pitch-In Canada, 1998, <http://www.pitch-in.ca>, (accessed May 15, 1999).
3. Canadian Council of Ministers of the Environment, 1998, *National Packaging Protocol 1996 Milestone Report, National Task Force on Packaging*, January, Winnipeg.

Table 7.4.8
Scrap and Recycled Tires in Canada[1]

Province	Used-tire management program	Program administration	Number of tires generated	Tire tax or levy	Total recovery rate	Recycling rate	Use as tire-derived fuel
			millions of PTEs[2]	dollars per new tire	percent		
Newfoundland	No	...	0.5	-	45	45	
Prince Edward Island	Yes	Department of the Environment	0.1	2	95	varies	varies
Nova Scotia	Yes	Multi-stakeholder board	0.9	3 - 9	82	82	-
New Brunswick	Yes	Multi-stakeholder board	0.7	3 - 9	130	130	-
Quebec	Yes	Multi-stakeholder council	6.0	3[3]	83	42	41
Ontario	No	...	10.0	-	25	25	..
Manitoba	Yes	Multi-stakeholder board	1.0	3	85	75	12
Saskatchewan	Yes	Multi-stakeholder board	1.0	3.50 - 35	65	..	75-80
Alberta	Yes	Multi-stakeholder association	2.5	4	80	80	-
British Columbia	Yes	Private contractor	3.6	3	90	72	18

Notes:
1. These data cover the period 1996 to 1998, depending on the provincial data source.
2. One PTE (passenger tire equivalent) represents an 'average' car tire. One truck tire is equivalent to approximately 5.8 PTEs. Numbers vary depending on the provincial data source.
3. Effective as of October 1, 1999, Quebec's fee will be used to finance an environmental fund.

Sources:
Hickman, Doug, 1999, *What Goes Around Comes Around*, Solid Waste and Recycling, June/July, Vol. 4, No. 3, Markam, Ontario.
Nova Scotia Department of the Environment, *1999 Interim Status Report of Solid Waste Resource Management in Nova Scotia*, <www.gov.ns.ca/envi/wasteman/status99.htm>, (accessed October 22, 1999).
Recyc-Québec, *Fiche d'information : Pneus*, <http://www.recyc-quebec.gouv.qc.ca/ficheinf/PNEUS.html>, (accessed May 19, 1999).
Mary Pysch, Ontario Ministry of the Environment, personal communication.
Manitoba Tire Stewardship Board, <http://www.escape.ca/~mbtirebd/results.htm>, (accessed October 22, 1999) and <http://www.gov.mb.ca/environ/pages/emd/pollprev/wrap/tire/bsnsplan.htm>, (accessed August 4, 1999).
Ron Harper, Manitoba Tire Stewardship Board, personal communication, June 28, 1999.
Kim Yee, Saskatchewan Ministry of the Environment and Resource Management, personal communication, May 1999.
The Tire Recycling Management Association of Alberta, *Annual Report*, October, 1996 to March 31 1997 <http www trma com> (accessed May 20 1999)
British Columbia Ministry of Environment, Lands and Parks, 1999, *Environmental Protection, Financial Incentives for Recycling Scrap Tires (FIRST) Program*, <http//www.elp.gov.bc.ca/epd/epdpa/pppm/ipshhp/tfifrstf.html>, (accessed October 22, 1999).

Text Box 7.4.8

Uses of Scrap Tires

Whole scrap tires are used in playground equipment, as dock bumpers, as crash barriers—and even for borders in landscaping.

Some scrap tires are shredded to produce door mats, handbags or floor coverings. Others are granulated to produce 'crumb rubber,' which is used in asphalt, tape, irrigation pipes, carpet underlay, footwear, recreational surfaces—and even in grass on golf courses and sports fields.

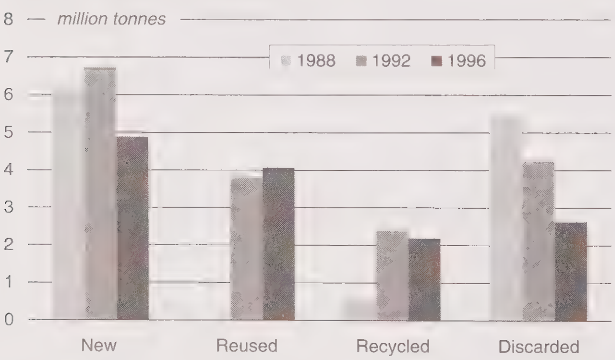
Scrap tires can be burned in order to recover energy (known as tire-derived fuel). While some Canadian provinces have allowed the use of scrap tires as fuel for pulp and paper mills, industrial boilers and cement kilns, Ontario has banned the incineration of tires.

With the introduction of steel-belted radial tires, the service life of tires has increased three-fold. This longer life span contributes to the first of the '3Rs', reduction. However, scrap tires are now much more difficult to recycle because they are made up of many components in variable mixtures. As a result, current technology has not been successful in reclaiming rubber from scrap tires so it can be reused to produce new tires. In general, sales of retreaded tires have declined over the past 15 years because the cost of buying new tires is comparable with the cost of retreads.

Source:
Recycling Council of Ontario, 1999, *Recyclable Materials: Scrap Tires*, <http://www.rco.on.ca/factsheet/recycle.html>, (accessed October 22, 1999).

Figure 7.4.4

Consumption and Disposition of Packaging, 1988, 1992 and 1996



Source:
Statistics Canada, Special Surveys Division, 1998, *National Packaging Monitoring System, 1996 Results*, prepared for Canadian Council of Ministers of the Environment, February, Ottawa.

Text Box 7.4.9

What is packaging?

The term 'packaging' refers to all materials, containers and other components that are used in the containment, protection, movement and display of a product or commodity.

The basic materials of packaging include paper, paperboard, cellophane, steel, aluminum, glass, wood, textiles and plastics.

Common types of packaging include wraps, strapping, bags, pouches, cartons, boxes, cans, bottles, pails, drums and barrels. Pallets and bins made of wood, metal or plastic are also used for shipping and are often reused.

Source:
Statistics Canada, Small Business and Special Surveys Division,1998, *1996 National Packaging Survey: Final Estimates*, February, Ottawa.

The amounts of reused and recycled packaging varied by material: the largest reductions in disposal from 1988 to 1996 were metals (80%), paper (60%) and glass (62%) (Table 7.4.9). The reduction was a result of increased recycling and reuse and the switch from heavier to lighter packaging materials.

7.4.5 Environmental and energy research and development

Government and business carry out research and development (R&D)[1] to prevent or limit the negative impacts of human activity on the environment.

Expenditures on environmental R&D

Federal government[2]

Intramural environmental protection R&D[3] (i.e., conducted within the scope of federal programs) has represented some 6% of total federal intramural expenditures since 1995–96 (Table 7.4.10). These expenditures have dropped 14.1% since 1995–96. As well, federal extramural expenditures (i.e., R&D conducted outside federal programs) fell 12.0% between 1995–96 and 1998–99.

1. See subsection 4.3.1–**Research and development**.
2. Statistics on government R&D expenditures for environmental protection and pollution abatement and control are available only for the federal government.
3. Federal intramural R&D includes only R&D directly performed by federal departments.

Table 7.4.9
Consumption and Disposition of Packaging, 1988, 1992 and 1996

Material	Total consumed[1]			Total reused			Total recycled			Total discarded		
	1988	1992	1996	1988	1992	1996	1988	1992	1996	1988	1992	1996
	thousand tonnes											
Wood (pallets, boxes)	1 019.9	1 839.2	2 484.1	312.8	942.1	1 704.0	22.4	64.2	189.0	684.7	832.9	591.2
Paper (boxes, labels, and corrugated cardboard)	2 363.9	3 683.7	2 441.3	-	571.2	345.3	437.1	1 599.9	1 328.1	1 926.8	1 512.6	767.9
Glass	821.4	1 950.6	1 382.0	89.9	1 166.2	823.0	56.5	291.7	303.7	675.0	492.7	255.3
Plastic (containers and wrap)	1 043.5	1 618.8	1 288.8	-	543.9	451.3	21.7	135.8	133.8	1 021.8	939.1	703.7
Metal (excluding aluminum)	959.0	954.9	963.1	-	471.3	660.1	23.7	211.2	114.5	935.3	272.4	188.4
Aluminum	76.3	100.0	129.9	-	7.4	21.1	32.7	92.4	60.7	43.7	--	48.0
Multi-material	112.2	184.1	145.6	-	36.0	34.0	-	1.2	69.6	112.2	146.9	42.0
Textiles	19.8	8.6	15.4	-	3.4	5.5	-	--	1.4	19.8	5.1	8.4
Other	..	108.6	55.7	..	67.8	22.0	..	3.8	-	-	37.0	33.7
Total	**6 416.1**	**10 448.4**	**8 905.7**	**402.7**	**3 809.2**	**4 066.2**	**594.1**	**2 400.1**	**2 200.7**	**5 419.2**	**4 238.7**	**2 638.5**

Notes:
Calculation of weight: 'discarded' equals 'consumed' minus 'reused' minus 'recycled'.
1. Includes the following: new packaging; packaging imports minus exports; reused packaging; recycled packaging from industry, households, commercial and institutional establishments; and discarded packaging.
Sources:
Statistics Canada, 1998, *National Packaging Monitoring System, 1996 Results*, prepared for the Canadian Council of Ministers of the Environment, Ottawa.
Canadian Council of Ministers of the Environment, 1988, *National Packaging Protocol-1992 Milestone Report*, Winnipeg.

Table 7.4.10
Federal Government R&D Expenditures on Environmental Protection, 1995-96 to 1998-99

Fiscal year[1]	R&D expenditures on environmental protection		Total R&D expenditures		R&D on environmental protection as a share of total R&D expenditures	
	Intra-mural[2]	Extra-mural[3]	Intra-mural[2]	Extra-mural[3]	Intra-mural[2]	Extra-mural[3]
	million dollars				percent	
1995-96	99	50	1 598	1 689	6.2	3.0
1996-97[r]	96	45	1 636	1 557	5.9	2.9
1997-98[p]	89	46	1 486	1 575	6.0	2.9
1998-99[e]	85	44	1 472	1 729	5.8	2.5

Notes:
1. Estimates are provided on a fiscal year basis, year ending closest to March 31.
2. Excludes non-program (indirect) costs.
3. Federal government expenditures for R&D performed outside federal government (indirect costs).
Source:
Statistics Canada, 1999, *Federal Scientific Activities, 1998-99[e]*, Catalogue No. 88-204-XPB, Ottawa.

Industrial research institutes and companies

In 1995, companies devoted $152.3 million to R&D environmental protection (Table 7.4.11). Although this represented a 26.3% increase over 1993, it was small compared with total R&D expenditures by industrial research institutes and industry. R&D directly devoted to environmental protection only represented 2% of this sector's total 1995 R&D expenditures,[1] compared with 6% for the federal government's R&D.

The engineering offices and scientific services industry was responsible for the largest environmental R&D expenditures over the 1990–1995 period, particularly in 1995 (Table 7.4.11). But Paper and Allied Products firms devoted their biggest share of total R&D expenditures to environmental protection in 1995 (9.6%) after industrial research institutes (11.8%).

1. For further information, see Statistics Canada, 1997, "Research and Development (R&D) Expenditures for Environmental Protection (EP) in Canadian Industry, 1995," *Science Statistics*, Vol. 21, No. 12, Catalogue No. 88-001-XPB, Ottawa.

Table 7.4.11
Industrial R&D Expenditures on Environmental Protection, 1990-1995

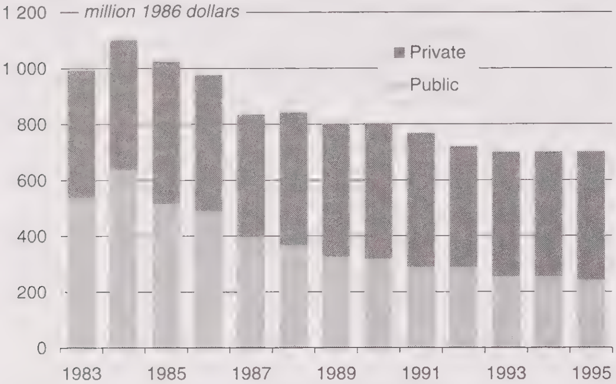
Industry	1990	1991	1993	1995
	million dollars			
Mining	7.6	8.0	7.8	5.8
Crude Petroleum and Natural Gas	--	0.8	4.0	6.5
Food; Beverage; Tobacco Products	0.9	0.1	1.9	1.7
Paper and Allied Products	2.7	3.6	8.7	6.4
Primary Metals	5.7	19.8	9.5	10.3
Fabricated Metal Products	0.9	4.1	3.4	3.3
Machinery	6.2	11.0	7.7	9.6
Transportation Equipment	5.3	12.7	3.3	12.3
Refined Petroleum and Coal Products	4.7	7.8	8.4	5.8
Chemical and Chemical Products	11.2	6.9	11.4	12.1
Other Manufacturing Industries	4.5	5.8	6.3	6.5
Electric Power Systems; Gas Distribution Systems; Other Utility	12.5	11.5	6.8	4.9
Offices of engineers and other scientific services	12.7	17.1	27.5	44.7
Other industries	11.8	5.6	14.0	22.3
R&D performed by firms	**86.7**	**114.8**	**120.6**	**152.3**
R&D performed by industrial research institutes	6.3	14.7	14.9	13.1
Total	**93.0**	**129.6**	**135.5**	**165.4**

Note:
Industry expenditures for R&D include intramural expenditures (i.e., performed within the firm).
Source:
Statistics Canada, 1997, "Research and Development Expenditures for Environmental Protection in Canadian Industry, 1995," *Science Statistics*, Vol. 21, No. 12, Catalogue No. 88-001-XPB, Ottawa.

R&D on energy technologies

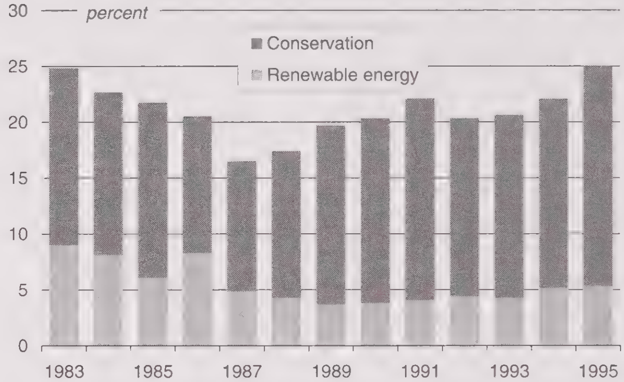
Governments and industry contribute to improving the environment by conducting research and development (R&D) on energy technologies. These technologies include energy conservation, fossil fuel recovery, renewable energy (e.g., solar, photoelectric, wind, tidal, biomass, geothermal and hydro energy), nuclear power (fission and fusion), and other fuel systems. Expenditures on energy R&D, while not specifically aimed at climate change, may contribute to a reduction in greenhouse gases through lower fossil fuel consumption.

Figure 7.4.5
Private and Government Energy R&D Expenditures, 1983-1995



Source:
Natural Resources Canada, 1997, *A Review of Canadian Energy Research and Development Expenditures 1983-1995*, Office of Energy Research and Development, Ottawa.

Figure 7.4.6
Share of Total Government and Private R&D for Renewable Energy and Conservation, 1983-1995



Source:
Natural Resources Canada, 1997, *A Review of Canadian Energy Research and Development Expenditures 1983-1995*, Office of Energy Research and Development, Ottawa.

After adjusting for inflation, energy R&D expenditures[1] have declined from over $1.1 billion in 1984 to about $700 million in 1995 (Figure 7.4.5). The federal government provided 88% of the total government R&D expenditures on energy in 1995.

The proportion of total government and private R&D devoted to renewable energy sources has declined from about 9% in 1983 to 5% in 1995 (Figure 7.4.6). During this period, the proportion of the total spent on energy conservation[2] has increased from 16% to 20%.

In the last 30 years, the federal government's energy policies have shifted from concerns about a secure energy supply in the late 1970s and 1980s to focus on economic and regional development in the late 1980s and early 1990s and on conservation in the late 1990s. The decline in R&D expenditures has been greatest for fossil fuels and nuclear energy, with total government R&D energy funding falling from 86% in 1986 to 63% by 1997 (Table 7.4.12).

Private-sector energy R&D has remained relatively stable since 1983. R&D on fossil fuels declined abruptly after 1985 when petroleum prices fell. This fall was compensated by a relative increase in R&D on electricity as well as energy conservation (Table 7.4.13).

1. Natural Resources Canada, 1997, *A Review of Canadian Energy Research and Development Expenditures 1983–1995*, Office of Energy Research and Development, Ottawa.
2. Energy conservation (or efficiency) consists of a variety of technologies used to conserve energy (such as in residential and commercial buildings) or to improve the energy efficiency in industrial processes.

Table 7.4.12
Energy-related R&D by Federal and Provincial Governments, 1983-1997

Year	Area of technology						
	Renewable	Conservation	Electricity	Fossil fuel	Nuclear	Others	**Total**
	million 1986 dollars						
1983	68.9	79.3	9.6	148.8	206.6	22.0	**535.2**
1984	66.8	89.0	10.8	234.0	214.6	20.0	**635.2**
1985	34.6	81.7	9.7	172.5	205.5	9.3	**513.3**
1986	19.8	32.6	7.7	227.1	192.6	8.3	**488.1**
1987	17.0	33.0	5.2	163.7	169.3	7.1	**395.3**
1988	15.5	35.0	5.0	158.1	147.2	5.6	**366.4**
1989	12.8	33.7	4.6	119.8	136.9	16.3	**324.1**
1990	10.5	33.0	3.8	123.3	135.6	10.5	**316.7**
1991	9.7	29.1	3.2	111.7	123.1	10.3	**287.1**
1992	11.2	24.6	8.7	91.2	133.4	17.9	**287.0**
1993	10.0	27.3	2.4	72.4	126.2	14.2	**252.5**
1994	11.6	31.4	1.3	56.4	127.5	24.3	**252.5**
1995	10.1	27.3	0.7	63.4	123.1	16.6	**241.2**
1996	10.8	28.2	0.3	53.1	98.0	23.8	**214.2**
1997	9.9	33.5	3.2	48.3	84.5	30.9	**210.3**

Source:
Natural Resources Canada, Office of Energy Research and Development.

Table 7.4.13
Private-sector Energy Research and Development, 1983-1995

Year	Area of technology						
	Renewable	Conservation	Electricity	Fossil fuel	Nuclear	Others	**Total**
	million 1986 dollars						
1983	20.0	78.4	46.4	240.1	50.2	22.1	**457.3**
1984	22.6	71.7	62.9	229.5	58.2	22.1	**467.0**
1985	27.3	79.5	64.5	270.2	49.7	20.1	**511.3**
1986	60.9	87.7	67.9	185.1	63.9	23.8	**489.3**
1987	23.2	65.0	101.5	151.8	50.0	48.9	**440.4**
1988	20.0	76.4	123.2	160.2	41.3	55.5	**476.6**
1989	16.4	95.1	121.3	162.4	41.0	41.6	**477.8**
1990	19.8	100.4	104.1	178.4	50.9	33.3	**486.8**
1991	21.4	110.1	96.9	159.7	62.3	31.6	**481.8**
1992	20.2	90.8	93.1	137.7	58.5	33.0	**433.3**
1993	19.7	87.7	94.9	152.3	48.7	44.9	**448.1**
1994	24.3	87.4	101.6	156.6	43.0	35.4	**448.4**
1995	26.8	111.5	127.8	132.5	29.5	32.2	**460.4**

Source:
Natural Resources Canada, Office of Energy Research and Development.

7.4.6 Environmental technologies used by industry

Companies adopt different practices aimed directly or indirectly at preventing or decreasing environmental degradation. The conventional method for handling pollution problems is to use end-of-pipe processes to treat waste. These are technologies or processes set up apart from the production process, serving solely to reduce levels of harmful substances created during normal production activities. Examples of such end-of-pipe processes include secondary waste water treatment facilities, scrubbers and incinerators.

However, it may be less costly and more efficient for companies to decrease waste production from the start by altering the production process, practising energy conservation and so forth. Over the past few years, there has been a shift towards the management and conservation of resources and the re-engineering of industrial processes in order to reduce the generation of pollutants and improve resource and energy efficiency. These technologies are known as pollution prevention (Text Box 7.4.10).

Recycling was the most popular pollution reduction method in 1996, followed by improved control over operations (Table 7.4.14). In the Pulp and Paper Industry, end-of-pipe processes were the most widely used (55.7%), although some pollution prevention methods were also reported more than 40% of the time.

Text Box 7.4.10
Pollution Prevention Methods

"Pollution prevention is the use of processes, practices, materials, products or types of energy that hinder or minimize production of pollutants, wastes and wastage, while providing a general decrease in threats to human and environmental well-being."[1] Examples of pollution prevention methods include the following:

- product modification;
- integrated change in the production process;
- improved control of operations;
- recycling, including recovery and reuse of materials and substances and recirculation of water;
- energy efficiency, including energy conservation, cogeneration, use of renewable energies, transformation of waste into energy, and incineration of organic matter;
- substitution or reduction of materials, raw materials and solvents; and
- prevention of leaks and spills.

Pollution prevention is sometimes characterized by economic as well as environmental benefits. For instance, energy conservation practices allow businesses to cut electricity costs while reducing the use of energy resources.

1. Government of Canada, 1995, *Pollution Prevention—A Federal Action Strategy*, Ottawa.

Table 7.4.14
Frequency of Pollution Abatement Practices by Industry, 1996

Industry	End-of-pipe process	End product modification	Pollution prevention: Integrated production process change	Improved control of operations	Recycling	Energy efficiency	Material or solvent substitution	Other
	percent of total number declared							
Logging	33.3	4.2	4.2	62.5	45.8	25.0	16.7	-
Mining	39.4	4.5	22.7	48.5	57.6	42.4	27.3	21.2
Crude Petroleum and Natural Gas	58.6	3.4	41.4	79.3	65.5	75.9	41.4	-
Food	39.0	11.7	24.7	51.9	59.7	42.9	28.6	6.5
Beverage	40.0	12.5	42.5	37.5	82.5	42.5	15.0	5.0
Pulp and Paper	55.7	5.1	40.5	50.6	46.8	36.7	26.6	12.7
Primary Metals	48.1	5.1	36.7	49.4	69.6	38.0	39.2	6.3
Transportation Equipment	39.2	17.6	43.1	51.0	80.4	56.9	56.9	5.9
Non-Metallic Mineral Products	45.5	9.1	30.3	42.4	72.7	39.4	39.4	9.1
Refined Petroleum and Coal Products	43.8	12.5	12.5	75.0	50.0	43.8	18.8	12.5
Chemical and Chemical Products	32.2	20.0	35.7	62.2	70.8	29.6	43.5	17.4
Other Manufacturing[1]	19.2	12.7	28.5	38.5	71.9	38.1	39.6	4.2
Pipeline Transport; Gas Distribution Systems	53.6	3.6	7.1	75.0	67.9	71.4	42.9	3.6
Electric Power Systems	29.4	11.8	23.5	47.1	76.5	82.4	58.8	5.9
Total	**35.9**	**10.9**	**30.6**	**49.2**	**66.2**	**41.7**	**36.5**	**8.4**

Notes:
Figures may not add up to totals because an establishment may report more than one practice.
1. Other manufacturing includes all other manufacturing industries not already specified.
Source:
Statistics Canada, Environment Accounts and Statistics Division, Survey of Environmental Protection Expenditures.

Certain environmental practices of business gave rise to the use of specific technologies aimed at preventing or abating pollution in water and air. Examples of such technologies appear in Table 7.4.15 and Text Box 7.4.11.

In 1996, 48% of industrial biotechnological applications were environmental in nature (e.g., activated sludges, aerated ponds and lagoons).[1] In 1997, environment-related biotechnological R&D rose to $6 million, or 1% of total industrial R&D expenditures on biotechnology.[2]

7.4.7 Renewable energy sources

As Canada's population and economy continue to grow, so will the demand for energy. We continue to rely on finite non-renewable fossil fuels such as coal and oil for much of our energy. The use of these fossil fuels produces air pollutants that affect our health as well as the environment.

Governments and industry are developing alternative sustainable energy sources to deal with the problems associated with fossil fuels. These renewable energy sources include battery-operated vehicles, hydrogen-fuel cells, wind energy, solar energy, and various types of bioenergy. Currently, renewable energy sources account for about 18% of Canada's primary energy supply.[3]

1. For further information, see Statistics Canada, 1998, *Biotechnology Use by Canadian Industry, 1996*, Catalogue No. ST-98-05, Ottawa. See also Text Box 4.3.3 of section 4.3–**Science and technology** for a definition of environmental biotechnologies.
2. Government of Canada, 1999, *Canadian Biotechnology Statistics*, Ottawa.
3. See section 5.6–**Energy resources** for a discussion about types of renewable energy.

Table 7.4.15
Water and Air Pollution Abatement Technologies,[1] 1994-1996

Technology	Category of treatment	Technology as a share of total number of technologies per medium (percent)
Reduction of water pollution		
Neutralization	Chemical	11
Primary clarification	Physical	7
Oil/water separation	Physical	6
Activated sludge	Biological	5
Aeration pond	Biological	4
Aerobic lagoon	Biological	4
Reduction of air pollution		
Dust collector	Physical	20
Air or wet scrubbing	Chemical	14
Bag house	Physical	8
Flare system	Thermal	6
Electrostatic precipitation	Physical	4
Desulphurization	Chemical	2

Notes:
Figures represent average frequencies for the period.
1. Technologies most frequently used by businesses.
Source:
Statistics Canada, Environment Accounts and Statistics Division, Survey of Environmental Protection Expenditures.

Text Box 7.4.11
Water and Air Pollution Reduction Processes

Water and air pollution can be treated physically, chemically, biologically or thermally (Table 7.4.15).

The most widespread water pollution reduction methods include the following:

- *Neutralization*: adjusting pH by adding bases or acids to water; restoring effluent's pH to 7 before discharging it into the municipal sewer system.
- *Primary clarification of liquid waste*: letting solid particles settle to the bottom of a large basin to remove solids and clarify surface waters; separating oil and water, often through gravity deposition.
- *Activated sludges, aerated ponds and lagoons*: using micro-organisms to attack pollutants. (Bacteria assimilate and break down carbon-rich organic matter in sewage. Some bacteria are aerobic, requiring oxygen to do their work, while other bacteria work anaerobically, in the absence of oxygen.)

Air pollution reduction methods include the following:

- *Dust collectors*: recovering gases by sucking them into a hood and sending them to gas treatment equipment or a gas treatment facility.
- *Bag house*: filtering gases through a series of filter cartridges within an enclosed space. (When gases must pass between the different cartridges, dust and particles are trapped in the many cartridge folds; discharged gases contain very few large particles.)
- *Electrostatic precipitator*: inducing electrostatic charge in gases to be treated. (Charged particles adhere to elements bearing opposite charges within the enclosure; since opposite charges attract, particles are thus extracted from gases prior to discharge.)
- *Flare system*: eliminating combustible gases by burning them in open spaces. (In contrast with incineration, where pollutants are burned in enclosed spaces.)
- *Wet or dry gas purification*: passing gases through a filtering environment in a packed or spray tower. (When gases penetrate the packed tower, a fluid or another gas arrives in a countercurrent to absorb and remove toxic gases.)

Battery-operated vehicles

At present, the only practical way to achieve zero emissions from light-duty vehicles is to use electric storage batteries. In 1999, the Montréal 2000 Electric Vehicle Fleet Project was launched to help reduce urban smog. The aim of this project is to prove that battery-powered cars, trucks and vans can replace vehicles powered by internal combustion engines in real-life situations. A battery-powered car emits about 3.8 tonnes less carbon dioxide per year than a conventional gasoline vehicle.[1]

The Montréal 2000 Electric Vehicles Project is designed to bring together 15 to 20 organizations with commercial or institutional vehicle fleets that are interested in acquiring electric vehicles.

Hydrogen-fuel cells

A fuel cell is an electrochemical device in which hydrogen and oxygen are combined to produce electricity, with no by-products except water. This technology is seen as a cleaner alternative to the conventional internal combustion engine. Although this technology is very promising, there are environmental effects that vary depending upon the source of hydrogen.

The two main hydrogen production processes used in Canada are the electrolysis of water and the steam reforming of natural gas. The electrolysis of water does not emit pollutants or generate greenhouse gases; the natural gas process generates nitrous oxide and carbon dioxide as by-products. However, one must take a broader perspective in evaluating the environmental effects. A life-cycle analysis considers the source of electricity used for the electrolysis. Hydro-electricity generation produces no direct emissions[2] whereas electricity produced from the combustion of fossil fuels results in considerable pollution and greenhouse gases.

Fuel cells are at least twice as efficient as vehicles that use natural gas in conventional internal combustion engines. Therefore, the technology is environmentally superior

1. Environment Canada, 1999, *The Montréal 2000 Electric Vehicles Project*, <http://www.ec.gc.ca/press/evp1_n_e.htm>, (accessed September 13, 1999).

2. This is not to say that hydro-electricity generation has no environmental consequences. It involves flooding vast areas resulting in the disturbance of the natural ecosystem and giving rise to the generation of some amount of methane. However, in terms of air pollution and greenhouse gas generation, it is very clean.

Table 7.4.16
Full Life-cycle CO_2 and ODS Emissions From Buses

Fuel-cell technology	Energy source to generate hydrogen	CO_2	ODS[1]
		grams per kilometre	
Electrolysis of water	Hydro[2]	0.22	0.003
Electrolysis of water	Natural gas	2 936.00	2.130
Electrolysis of water	Coal	5 180.00	5.360
Reforming of natural gas	Hydro[2]	685.00	1.660
Reforming of natural gas	Mix of primary fuels[3]	836.00	1.860
Internal combustion-engine bus[4]	Diesel	2 462.00	16.700

Notes:
1. Contribution to ground-level ozone.
2. Emissions from truck transport of hydrogen to site.
3. Current mix in Alberta: 89% coal and 11% natural gas.
4. Average of diesel buses in Canada, for sake of comparison.

Source:
Canadian Energy Research Institute, *The Environmental Benefits and Economics of Hydrogen as a Vehicle Fuel in Canada*, Study No. 82, January, 1998 ISBN 1-896091-32-6.

simply by virtue of the reduction in fuel requirements, regardless of the source of hydrogen. Even if electricity used in the steam reforming of natural gas comes from fossil fuel sources, CO_2 emissions from buses can be reduced by almost two-thirds by using fuel-cell technology, compared with diesel internal combustion engines (Table 7.4.16).

The greatest use of fuel cells is in public transit motor vehicles. However, the main barrier to the adoption of fuel-cell technology is the cost. For example, buses powered by fuel cells are four times as expensive as conventional ones.

Wind energy

The Canadian Wind Energy Association reports that Canada currently has about 81 megawatts of installed wind-generation capacity—enough to supply the electricity requirements of some 29 000 households.[1] Although wind energy has dropped in price from 20 cents per kilowatt hour in 1983 to between 5 cents and 6 cents in 1999, it is still not competitive with traditional sources for most uses. Wind–diesel projects in remote northern locations have demonstrated that this energy source can be cost-effective in the face of the high cost of transporting diesel fuel.

Two of the largest Canadian wind energy installations are Cowley Ridge Wind Farm in Alberta (with a capacity of 24 megawatts) and the Nordais Wind Park on Quebec's Gaspé Peninsula. When completed, the Nordais Wind Park will be one of the world's largest wind parks, with 133 windmills generating some 100 megawatts.[2] Hydro-Québec plans to develop 250 megawatts of installed wind capacity, beginning in 2000, at the rate of 25 megawatts per year.

1. Canadian Wind Energy Association, 1999, *Quick Facts*, <http://www.canwea.ca/quickfacts.htm>, (accessed September 7, 1999).
2. Environline, 1999, *Energy Issues*, Vol. 10, No. 11.

Text Box 7.4.12
Solar Energy

There are three types of solar energy technology: passive solar energy, active solar energy systems and photovoltaic technology.

Passive solar energy is used to heat or cool buildings, or heat water through architectural designs in which no mechanical methods are used. For example, south-facing windows used to increase solar gain are one example of passive solar energy.

Active solar energy systems directly convert solar radiation into thermal energy, which can be used to heat water or air. Active solar technologies are used to heat water, including swimming pools, and ventilation air for heating systems.

Photovoltaic technology converts sunlight directly into electricity and is ideal for energy supply in remote communities. Other applications of photovoltaics are solar-powered calculators and watches.

Solar energy

Canada has access to another renewable energy source, the sun. There are many ways to convert sunlight into other forms of energy (Text Box 7.4.12).

Residential solar water heaters are one of the most important applications of solar-based energy. Over the next 20 years, approximately 165 000 solar water heater systems will be installed in Canada.[3]

Solar photovoltaic modules, which convert sunlight directly into electricity using solar cells made from semiconductor materials, are used in many applications throughout Canada (Text Box 7.4.13). Photovoltaic production of electricity produces no greenhouse gas emissions.

Biomass energy

All kinds of plant and animal matter can be defined as biomass. Plant waste can be converted into energy and electricity. In 1995, 6.6% of Canada's primary energy was derived from converting biomass into energy.[4] The forest products and pulp and paper industries produce most of Canada's biomass energy. By using their waste material, these industries produce steam and electricity, to use themselves and to sell to others.

The ethanol and methane produced in municipal landfill sites are examples of fuel extracted from biomass.

3. Natural Resources Canada, CANMET Energy Technology Centre, 1999, *S-2000 Program*, <http://www.nrcan.gc.ca/es/etb/cetc/cetc02.htm#renewwet>, (accessed September 7, 1999).
4. Natural Resources Canada (Energy), 1996, *Renewable Energy Strategy: Creating a New Momentum*, <http://www.nrcan.gc.ca/es/new/denis2.htm>, (accessed September 7, 1999).

Text Box 7.4.13
Photovoltaic Use in Canada

Natural Resources Canada is working with the government of the Northwest Territories to encourage the use of photovoltaics (PV) in remote Arctic regions. Activities include the installation of two photovoltaic cells for demonstration and research purposes at Arctic College in Iqaluit and at Aurora College in Inuvik.

The Canadian Coast Guard began converting navigational aids from battery to solar power in the early 1980s. More than 5 500 buoys, lights, fog signals and other navigational equipment on Canada's seacoasts, the Great Lakes and inland waters are powered by photovoltaics. PV generation has eliminated the need for about 1.5 million litres of diesel fuel and 20 000 batteries per year.

Sources:
Natural Resources Canada, 1996, *Renewable Energy Strategy, Creating the Momentum*, Ottawa.
Solar Energy Society of Canada Inc., 1998, "Solar Saves Coast Guard Millions," *SOL*, No. 107, September, 1998.

Ethanol

Gasoline-powered transportation vehicles accounted for almost 15% of Canada's greenhouse gas emissions in 1995. Apart from reducing our reliance on vehicles and increasing their efficiency, it is important to find alternatives to non-renewable fuels. One such effort is Canada's development of a market for biomass ethanol, which is made from renewable resources such as corn, wheat, barley, straw, wood waste and municipal solid waste. Apart from ethanol's property of reducing vehicle emissions, it can also play an important role in reducing greenhouse gases. Ethanol can currently be blended with gasoline up to a limit of 10% without requiring any changes to automobile engines. Some new automobiles will have the ability to use a blend of up to 85% ethanol.

Ethanol's effect in reducing greenhouse gas emissions depends heavily on the type of feedstock and the fuel required to produce it. For example, burning Canadian ethanol made from grain produces 17% to 30% less GHG than burning unblended gasoline. Gasoline with 10% ethanol results in a reduction of GHG emissions of 1.7% to 3.0%. Ethanol produced from wood and agricultural wastes instead of grain results in a fuel that generates 70% less GHG—or 7% less in a 1-in-10 blend with gasoline.

In 1997, Canada's domestic production of fuel ethanol was estimated at 28–30 million litres. Canada consumed 40 million litres, with the difference being supplied from the United States. Ethanol-blended gasoline accounted for about 1.8% of total Canadian gasoline sales in 1997 and the amount of gasoline actually displaced by ethanol was about 0.1% of total sales.[1] Ethanol-gasoline blends with a minimum of 5% ethanol are eligible to receive the EcoLogo environmental product label (see section 7.4.3-**Guidelines and standards**).

The amount of ethanol currently produced in Canada, for all markets, is 234 million litres (Table 7.4.17). By 2000, annual production should increase to 675 million litres with the addition of new ethanol plants.[2] This production is mainly from grain feedstock using environmental biotechnologies. Given that ethanol produced from corn and wheat is almost twice as expensive per unit of energy as unblended gasoline, Canadian federal R&D funding has been directed towards less expensive alternatives such as infected grains and low-cost wood and agricultural wastes.

Methane from landfills

Over the past decade, technologies have been developed to capture methane gas by drilling deep into landfill sites and pumping the gas out through a system of pipes. The

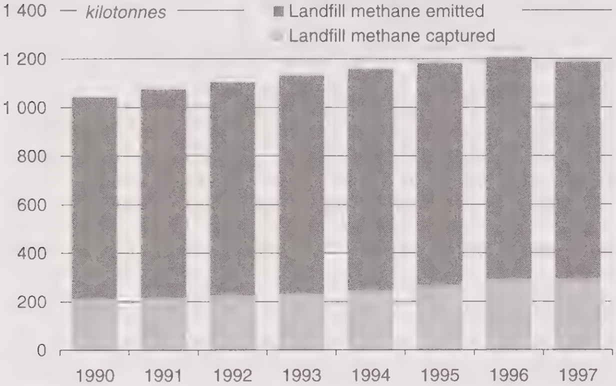
1. Interdepartmental Steering Committee on Ethanol, 1998, *Report to Ministers: The Federal Initiative to Encourage the Production and Use of Ethanol*, June 1998, Ottawa.
2. Ethanol Manufacturing in Canada, 1999, <www.greenfuels.org/ethaprod.html>, (accessed September 17, 1999).

Table 7.4.17
Ethanol Manufacturing in Canada

	Location	Capacity million litres	Source of biomass
Producer			
Mohawk Oil, Canada, Ltd.	Minnedosa, Man.	10	wheat
Pound-Maker Agventures, Ltd.	Lanigan, Sask.	12	wheat partnered with a cattle feedlot
Commercial Alcohols, Inc.	Tiverton, Ont.	23	corn
Commercial Alcohols, Inc.	Chatham, Ont.	150	corn
Agri-Partners International	Red Deer, Alta.	22	wheat
Tembec	Temiscaming, Que.	17	forestry products
Proposed developments			
Seaway Grain Processors, Inc.	Cornwall, Ont.	66	corn
Commercial Alcohols, Inc.	Varennes, Que.	150	corn
Commercial Alcohols, Inc.	Chatham, Ont.	300	corn
Metalore Resources, Inc.	..	75	wheat

Source:
Ethanol Manufacturing in Canada, <http://www.greenfuels.org/ethaprod.html>, (accessed September 17, 1999).

Figure 7.4.7
Methane Captured from Landfills, 1990-1997



Source:
National Climate Change Process, 1998, Municipalities Issue Table Foundation Paper, Appendix A: Landfill Gas Subcommittee Foundation Paper.

captured gas is either burned off or used as fuel in producing electricity or heating buildings.

The decomposition of waste in landfills produces a gas that is composed primarily of methane and carbon dioxide, both of which are greenhouse gases contributing to climate change.[1] Gas emissions from Canada's landfills account for 26% of the human activity-sourced methane in Canada.[2] Estimates have shown that over 25 million tonnes of CO_2 equivalent are generated annually from Canadian landfills.

Thirty-three landfills in Canada are now capturing this harmful emission, resulting in a reduction of greenhouse gas emissions of 6 megatonnes per year of CO_2 equivalent. However, this was only 25% of the total landfill methane generated in 1997 (Figure 7.4.7). Currently, over 82 megawatts of electricity are produced from landfill gas in Canada, enough electrical power to meet the needs of over 50 000 homes (Text Box 7.4.14).[3]

Text Box 7.4.14
Landfill Sites Using Methane Gas for Electricity Generation

- **Clover Bar Landfill Gas to Energy Project, Edmonton, Alta.:** The landfill gas is fed to an existing electrical-generating station, providing 0.9% of the fuel and producing about 6 megawatts of electricity. (Annual GHG reduction: 182 000 tonnes of CO_2 equivalent)
- **Lachenaie Landfill Gas to Energy Project, Lachenaie, Que.:** The landfill gas from the private landfill is used to produce 4 megawatts of electricity. (Annual GHG reduction: 250 000 tonnes of CO_2 equivalent)
- **Complexe Environnemental de Saint-Michel Landfill Gas to Energy Project, Montréal, Que.:** This project produces 25 megawatts of electricity from a landfill in the centre of urban Montréal. (Annual GHG reduction: 1.1 million tonnes of CO_2 equivalent)
- **Keele Valley Landfill Gas to Energy Project, Toronto, Ont.:** The largest landfill gas utilization facility in Canada produces 30 megawatts of electricity for the City of Toronto. (Annual GHG reduction: over 1 million tonnes of CO_2 equivalent)
- **Jackman Landfill Site, Langley, B.C.:** Landfill gas feeds a boiler to generate heat for a greenhouse during the winter and cool summer evenings while the carbon dioxide generated in the boiler is used to enhance plant growth. (Annual GHG reduction: 18 000 tonnes of CO_2 equivalent)
- **Port Mann Landfill Gas to Energy Project, Surrey, B.C.:** Landfill gas is utilized as fuel for wallboard manufacturing at Georgia Pacific Canada Inc. (Annual GHG reduction: 40 000 tonnes of CO_2 equivalent)

Source:
Environment Canada, 1999, *Landfill Gas Utilization*, <http://www.ec.gc.ca/nopp/lfg/bulletin/indexe.htm>, (accessed June 8, 1999).

1. See subsection 6.1.2–**Greenhouse gas emissions**.
2. Environment Canada, 1999, *Landfill Gas Utilization*, <www.ec.gc.ca/nopp/lfg/bulletin/indexe.htm>, (accessed June 9, 1999).
3. Environment Canada, Six successful landfill gas utilization projects demonstrate early actions to reduce greenhouse gases, <http://www.ec.gc.ca/press/lfg_m_e.htm>, (accessed April 12, 2000).

7.5 Public participation

In recent decades, there has been a movement towards more public participation in environmental issues as well as in the environmental decision-making process. Participation is fuelled by the public's perception of the importance of environmental issues. This is reflected both in the level of individual participation in various activities and in consumer behaviour.

Participation can take the form of direct involvement in the environmental movement through donating time or money to environmental organizations. It can also involve more active consumer behaviour such as purchasing energy-efficient products, participating in various recycling programs or using public transportation. Public participation also extends to nature-related activities (see section 7.6–**Recreation**) and educational programs (see section 7.7–**Environmental education**).

7.5.1 Public perception of the environment

Opinion polls from private polling firms show that the economy and unemployment have traditionally been considered the most important issues facing Canadians, although the environment was identified as the most important issue in 1989 and 1990[1] (Figure 7.5.1). When asked about the environment in 1997, 9 out of 10 Canadians indicated they felt "a great deal of concern" or "a fair amount of concern" about the state of the environment.[2]

Personal health also drives public opinion about the environment. In 1998, Canadians identified environmental pollution as the most important health risk factor (Figure 7.5.2).

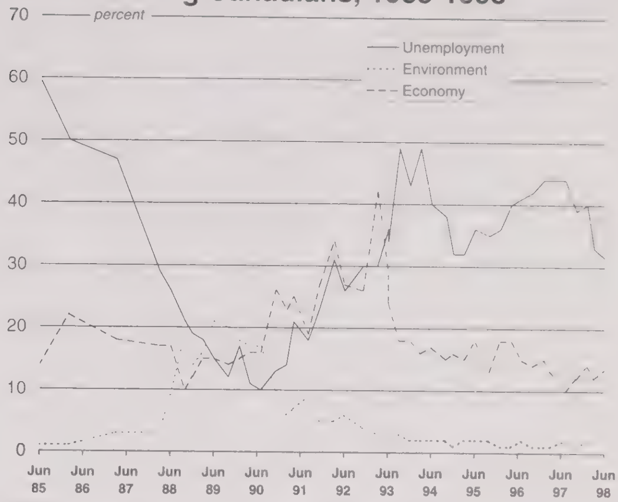
Public expectations and willingness to act

Although most Canadians believe that they can do something to help improve the environment, the numbers have been dropping recently. In 1998, public opinion poll data showed that 65% of those surveyed felt this way, compared with 75% in 1996 (Table 7.5.1).

Many Canadians feel that protecting the environment begins with the individual. From 1992 to 1996, most Canadians felt that individuals were responsible for protecting the environment.[3] However, this changed in 1998, when federal and provincial governments were perceived to have most of the responsibility (Figure 7.5.3).

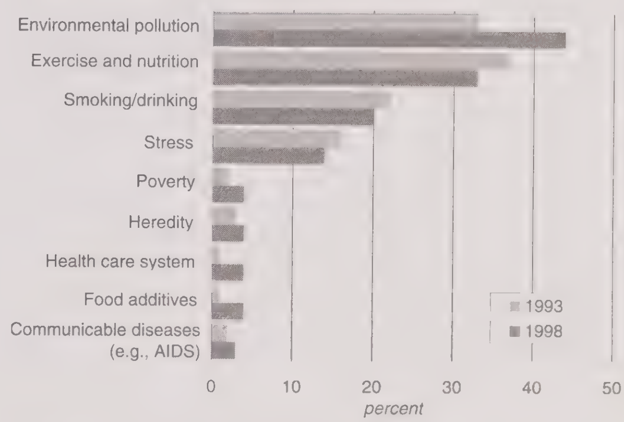
1. Environics International Ltd., 1998, *Focus Canada*, Toronto.
2. Environics International Ltd., 1997, *Canadians and the Environment, 1997, The State of Environmental Citizenship. A Report to Environment Canada*, Toronto.
3. Environics International Ltd., 1998, *op. cit.*

Figure 7.5.1
Public Perception of the Most Important Issues Facing Canadians, 1985-1998



Source:
Environics International Ltd., 1998, *Focus Canada*, Toronto.

Figure 7.5.2
Public Perception of the Most Important Health Risk Factors, 1993 and 1998



Sources:
Angus McAllister, Research Director, Environics International Ltd., personal communication.
Environics International Ltd., 1998, *Environmental Monitor*, Toronto.

7.5.2 Public participation by individuals and groups

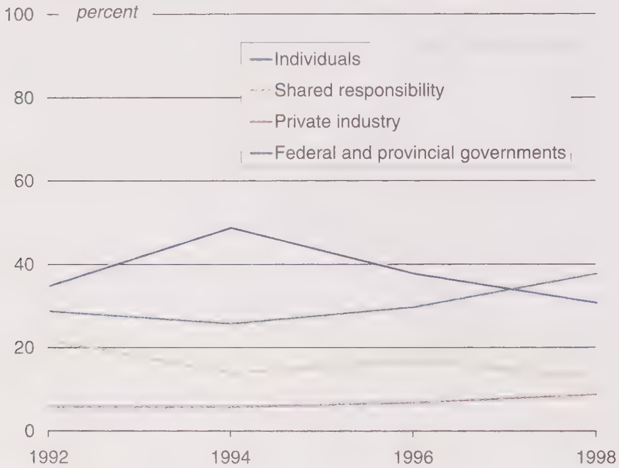
Many Canadians have integrated environmentally friendly household practices into their daily lives. Activities with the highest participation rates are those with attached economic incentives or disincentives (e.g., water- or energy-saving devices) or those supported by infrastructure (e.g., curbside recycling and composting programs).

Table 7.5.1
Canadians' Perception of Whether They Can Do Something to Improve the Environment, 1987-1998

Year	Yes	No
	percent	
1987	57	42
1988	61	38
1989	65	34
1990	73	27
1991	79	22
1992	76	24
1993	73	27
1994	..	..
1995	..	..
1996	75	25
1997	70	30
1998	65	34

Note:
Figures may not add up to 100% due to rounding.
Source:
Environics International Ltd., 1998, *Environmental Monitor*, Toronto.

Figure 7.5.3
Canadians' Perceptions of Who Should Protect the Environment, 1992-1998



Source:
Environics International Ltd., 1998, *Environmental Monitor*, Toronto.

Support of non-government environmental organizations

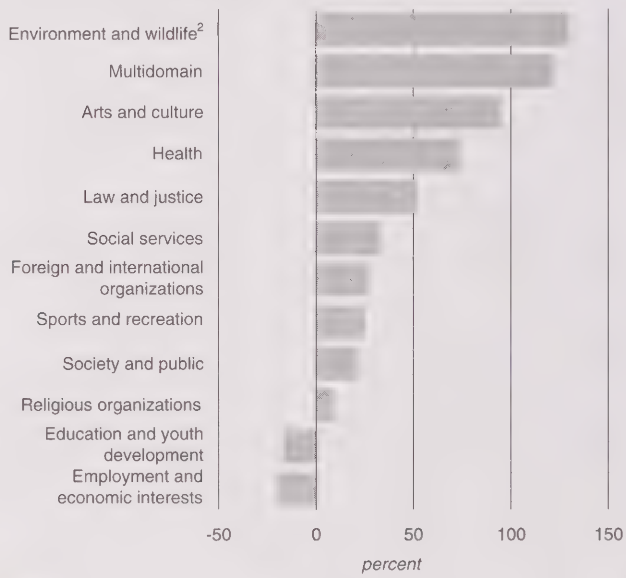
One form of individual participation is to support, through donations and volunteer time, the work of non-profit organizations that promote and provide environmental services. In 1997, non-government environmental organizations received approximately 2% of all individual donations to non-profit organizations (Table 7.5.2). Environmental and wildlife organizations showed the largest increase—

Table 7.5.2
Donations[1] by Type of Organization, 1997

Type of organization	Distribution of total number of donations (74 million)	Distribution of total amount of donations ($4.4 billion)
	percent	
Health	38	17
Social services	21	11
Religion	15	51
Education and research	7	4
Philanthropy and voluntarism	5	6
Culture and arts	4	3
International	2	3
Environment	2	2
Other[2]	2	2

Notes:
Figures may not add up to 100% due to rounding.
Estimates cover direct financial donations (excluding depositing spare change in cash boxes).
1. Donations (made by persons 15 years or over) to organizations promoting and providing the following services: environmental conservation; pollution control and prevention; environmental education and health; and animal protection.
2. Includes the following: development and housing; law, advocacy and politics; business and professional associations; and other organizations not elsewhere classified.
Source:
Statistics Canada, 1998, *Caring Canadians, Involved Canadians: Highlights from the 1997 National Survey of Giving, Volunteering and Participating*, Catalogue No. 71-542-XPE, Ottawa.

Figure 7.5.4
Change in Number of Volunteer[1] Events by Type of Organization, 1987-1997



Notes:
1. Canadian volunteers aged 15 and over.
2. Includes organizations promoting and providing the following services: environmental conservation; pollution control and prevention; environmental education and health; and animal protection.
Source:
Statistics Canada, 1998, *Caring Canadians, Involved Canadians: Highlights from the 1997 National Survey of Giving, Volunteering and Participating*, Catalogue No. 71-542-XPE, Ottawa.

130%—in volunteer events[1] from 1987 to 1997 (Figure 7.5.4).

Transportation modes

Despite the environmental benefits of using urban transit, data show that Canadians are using it less and less. Urban transit declined in popularity between 1950 and 1970 with the growth of suburbs and automobile ownership. There was a slight rebound in the 1980s, brought on by the energy crisis and environmental awareness, but since 1990 there has been a consistent decline in the number of passengers (see Table 4.8.5 in section 4.8–**Transportation**).

Driving continues to be the most common mode of transportation to work. In 1996, 73% of the working population drove their own automobiles to work; another 7% travelled as passengers, with someone else doing the driving. In the same year, 10% of the working population reported that they used some form of public transit to get to work, while 7% walked and 1% rode bicycles.

Canadians living in Ottawa–Hull, Toronto, Halifax, Montréal, Victoria, Winnipeg and Vancouver led the country in using alternative means of transportation to get to work (Table 7.5.3). In these census metropolitan areas (CMAs), the proportion of people who drove to work was below the national average of 73%; public transit was the most commonly used alternative form, particularly in Toronto (22.0%) and Montréal (20.3%).[2]

The environmental practices of individuals do not necessarily match public perception with regard to automobile use. Indeed, 45% of Canadians feel that driving a car is the personal action that contributes the most to environmental

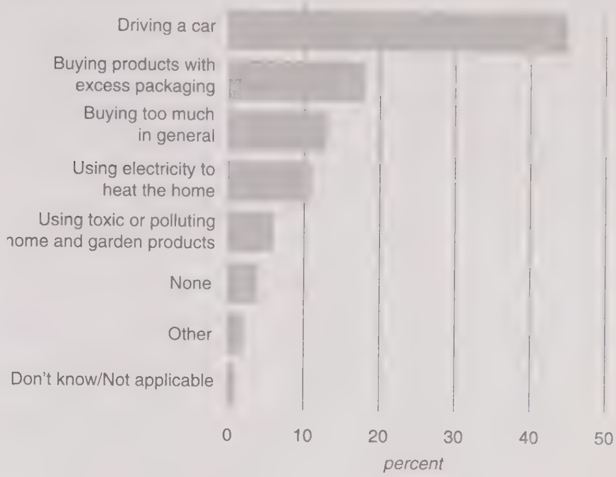
Table 7.5.3
Alternatives to Driving to Work by Census Metropolitan Area, 1996

Census metropolitan area	Public transit	Car, truck or van as passenger	Walk	Bicycle	Other	Total
			percent			
Ottawa-Hull	17.1	8.8	7.0	2.1	0.8	**35.7**
Toronto	22.0	6.7	4.6	0.8	0.7	**34.7**
Halifax	10.9	10.4	9.9	1.0	1.2	**33.4**
Montréal	20.3	5.5	5.9	1.0	0.6	**33.4**
Victoria	9.9	6.8	9.8	4.9	1.5	**32.9**
Winnipeg	14.4	9.0	6.2	1.4	0.9	**31.9**
Vancouver	14.3	6.6	5.8	1.7	1.0	**29.4**

Note:
Figures may not add up to totals due to rounding.
Source:
Statistics Canada, 1998, *Nation Series, Edition 4*, Catalogue No. 93F0020XCB, Ottawa.

1. In the National Survey of Giving, Volunteering and Participating, a volunteer event is defined as an involvement with an organization. It does not take into account the number of different activities performed nor the frequency, timing or duration of volunteering in that organization.
2. See section 4.8–**Transportation** for more information on alternative transportation modes.

Figure 7.5.5
Canadians' Perceptions of Personal Action that Causes the Most Stress on the Environment, 1998



Source:
Environics International Ltd., 1998, *Environmental Monitor*, Toronto.

damage (Figure 7.5.5). However, the convenience of driving outweighs the desire of many Canadians to take personal action to reduce environmental impact.

Household energy efficiency

Canadians are becoming more aware of their energy consumption at home, even though they do not consider that energy use in the home causes significant stress on the environment (Figure 7.5.5). Government programs such as the EnerGuide Program, the R-2000 Home Program and the Home Energy Retrofit Initiative help consumers make informed choices on energy-efficient alternatives (Text Box 7.5.1).

Energy-saving practices

Cost saving is a major incentive for reducing household energy use. Consumers invest in energy-saving devices and improved insulation for the express purpose of lowering their energy bill (Figure 7.5.6). In addition to cost savings, reduced household energy use can lead to reduced greenhouse gas emissions (see section 2.2–**Climate change**).

A large proportion of Canadian households own energy-intensive appliances, including washing machines, clothes dryers and dishwashers. The use of these appliances and energy-related practices is illustrated in Table 7.5.4.

Energy-efficient dwellings

Household energy use is also a function of the characteristics of the dwelling itself. The types of windows installed

Text Box 7.5.1
Federal Residential Energy Efficiency Initiatives

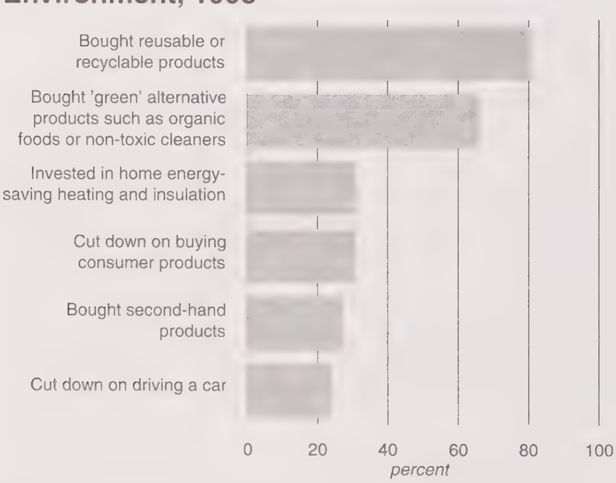
The Office of Energy Efficiency (OEE), Natural Resources Canada, supported the development, implementation and adoption of the **Model National Energy Code for Buildings**, which aims to increase the energy efficiency of new houses by specifying minimum energy efficiency requirements.

The OEE administers the following incentive programs for home owners:

- The **R-2000 Home Program** stimulates the construction and purchase of new energy-efficient houses at a voluntary standard that exceeds the efficiency level required by building codes.
- The **Home Energy Retrofit Initiative**, encourages owners of existing houses to improve energy efficiency when undertaking renovations or maintenance work.
- **EnerGuide** labels promote the production and purchase of more energy-efficient household appliances by showing the yearly energy consumption ratings of major residential appliances and equipment. Under the authority of the *Energy Efficiency Act*, the OEE sets energy performance regulations for certain types of residential energy-using equipment, thereby eliminating the most inefficient products from the market.

Source:
André Bourbeau, Office of Energy Efficiency, Natural Resources Canada, Ottawa, personal communication.

Figure 7.5.6
Individual Actions Taken to Protect the Environment, 1998



Source:
Environics International Ltd., 1998, *Environmental Monitor*, Toronto.

Table 7.5.4
Selected Energy-related Practices of Canadian Households, 1993

Practice	Households[1]
	percent
Households with washing machine	**79.0**
Water temperature used for washing:	
Hot	6.7
Warm	61.9
Cold	32.3
Water temperature used for rinsing:	
Hot	1.4
Warm	23.1
Cold	76.0
Households with clothes dryer	**73.8**
Average number of loads per week in winter:	
1 or fewer	13.4
2 or 3	28.3
4 or 5	21.9
6 or 7	16.3
8 to 13	14.8
14 or more	5.3
Average number of loads per week in summer:	
1 or fewer	36.3
2 or 3	25.7
4 or 5	17.2
6 or 7	10.0
8 to 13	8.3
14 or more	2.6
Households with dishwasher	**44.1**
Dishdrying:	
With heat	44.1
Without heat	55.9

Notes:
This table is based on the coverage of the 1993 Survey of Household Energy Use.
1. A household is a person or group of persons living in a single detached house, semi-detached house, row house, mobile home, duplex or apartment building.
Sources:
Natural Resources Canada, 1994, *1993 Survey of Household Energy Use: National Results*, Statistical Report 94-R-2-A, Ottawa.
Statistics Canada, Special Surveys Division.

and the structure of basements and attics help determine the amount of energy needed for heating and cooling the dwelling. For example, air tightness around windows is important in increasing energy efficiency. In 1993, double-paned windows were more commonly installed in Canadian dwellings. In comparison, less than 10% of dwellings had triple-paned windows (Table 7.5.5)

Various energy-efficient upgrades that are incorporated into home renovations offer significant energy savings in homes. These improvements, also known as 'retrofitting,' include increasing the air tightness around windows and doors and improving the insulation in basements, attics and crawl spaces (Table 7.5.6).

Recycling programs

In 1994, almost 70% of households had access to the most widely available recycling program, paper recycling, compared with less than 53% in 1991 (Table 7.5.7). The growth in access varied by region and by size of community. In Quebec and the Atlantic provinces, growth occurred in

Table 7.5.5
Selected Energy-saving Characteristics of Canadian Dwellings, 1993

Characteristic	Dwellings[1]
	percent
Windows	
Houses with one or more triple-paned windows	5.9
Houses with one or more double-paned windows	60.9
Houses with one or more single-paned windows	32.0
Air leaks and condensation	
Air leaks or drafts around windows	36.8
No leaks	63.2
Basement or crawl space	
Houses with basement or crawl space	90.0
Houses with heated basement or crawl space	77.5
Entire basement or crawl space	66.2
More than one-half	5.5
One-half	4.4
Less than one-half	1.4

Notes:
This table is based on the coverage of the 1993 Survey of Household Energy Use.
1. A dwelling includes single detached house, semidetached house, row house, mobile home, duplex. Apartment buildings are excluded.
Sources:
Natural Resources Canada, 1994, *1993 Survey of Household Energy Use: National Results*, Statistical Report 94-R-2-A, Ottawa.
Statistics Canada, Special Surveys Division.

Table 7.5.6
Retrofit Activity, 1993

Activity	Dwellings[1]
	percent
Improvements in air-tightness of windows	36.6
Improvements in air-tightness of doors	46.0
Improvements to insulation of basement or crawl space walls	21.5
Improvements to insulation of roof, attic or crawl space	16.5
Improvements to insulation of the exterior walls of the house	13.5

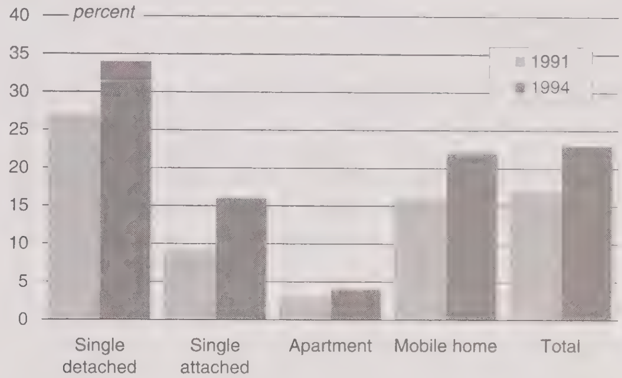
Notes:
This table is based on the coverage of the 1993 Survey of Household Energy Use. Figures are based on retrofit activity during the previous ten years (1984-1993).
1. A dwelling includes single detached house, semidetached house, row house, mobile home, duplex. Apartment buildings are excluded.
Sources:
Natural Resources Canada, 1994, *1993 Survey of Household Energy Use: National Results*, Statistical Report 94-R-2-A, Ottawa.
Statistics Canada, Special Surveys Division.

Table 7.5.7
Household Recycling Programs, 1991 and 1994

Recycling program	1991	1994
	percent of all Canadian households	
Access to recycling programs		
Paper	52.6	69.6
Metal cans	48.9	67.2
Glass bottles	49.9	67.4
Plastics	42.1	62.8
	percent of Canadian households with access	
Use of recycling programs		
Paper	85.8	83.1
Metal cans	86.2	83.5
Glass bottles	86.2	83.5
Plastics	84.7	81.7

Source:
Statistics Canada, 1995, *Households and the Environment 1994*, Catalogue No. 11-526, Ottawa.

Figure 7.5.7
Composting by Type of Dwelling, 1991 and 1994



Note:
Includes the use of a compost heap, compost container or compost service.
Source:
Statistics Canada, 1995, *Households and the Environment 1994*, Catalogue No. 11-526, Ottawa.

urban areas with a population of 100 000 and over. In Ontario and western Canada, where many major urban areas had recycling programs in 1991, growth occurred in smaller-sized communities and rural areas.

While access to curbside recycling has increased from 1991 to 1994, household use of such programs decreased over the same period (Table 7.5.7). In 1994, among households with access to paper recycling, 77% of those living in apartments recycled, compared with 86% of those living in single detached dwellings. However, much of the expanded access from 1991 to 1994 occurred in apartment blocks and areas with lower levels of convenience for users.[1]

1. Statistics Canada, 1995, *Households and the Environment 1994*, Catalogue No. 11-526, Ottawa.

Composting is another household activity that reduces the amount of waste going into landfills. In 1994, 22.7% of households used a compost heap, compost container or composting service, compared with 17.4% in 1991 (Figure 7.5.7). As of 1998, more than 1.2 million backyard composters had been distributed to Canadian households.[2] It is estimated that 30% to 50% of household waste can be composted—everything from leaves and grass clippings to vegetable and fruit peelings.

In 1998, 1.7 million tonnes of organic materials were composted in centralized composting operations, producing more than 850 000 tonnes of finished compost.[3,4] However,

2. The Composting Council of Canada, 1999, *Composting Increasing Across Canada: Fast Facts on Composting and its Development in Canada*, Toronto.
3. *Ibid.*
4. These data include households and commercial, industrial and institutional sources. They exclude organic material composted in backyards.

Table 7.5.8
Efforts in Green Consumerism, 1991 and 1994

Regular activity	1991	1994
	percent of Canadian households with children under 2 years of age	
Use disposable diapers		
All the time	62.9	76.9
Most of the time	10.2	9.5
Sometimes	20.2	11.1
Never	5.1	2.0
Child(ren) not in diapers	1.4	...
	percent of all Canadian households	
Purchase paper towels or toilet paper made from recycled paper	45.3	58.3
Take their own bags when shopping	24.6	24.4

Source:
Statistics Canada, 1995, *Households and the Environment 1994*, Catalogue No. 11-526, Ottawa.

it is estimated that less than 25% of the 7 million tonnes of organic material generated annually by Canadians is composted.

Green consumerism

Green consumerism remains a relatively underdeveloped market force; however, there are areas where individuals are making an impact through their purchasing patterns. According to a recent public opinion poll, 81% of Canadians purchased reusable or recyclable products and 66% bought 'greener' or more environmentally friendly products such as organically grown food and non-toxic cleaners (Figure 7.5.6).

Price and convenience are still factors in consumers' decisions to buy. For example, disposable diapers are a high convenience item that increased in popularity from 1991 to 1994. Consumers were also more likely to buy recycled paper products in 1994 than 1991 (Table 7.5.8).

Despite incentive programs implemented by some grocery chains, most Canadians continue to use plastic bags to carry purchases home. In 1991 and 1994, one-quarter of households reported regularly taking their own bags when shopping (Table 7.5.8).

7.5.3 Consultation in the environmental decision-making process

In addition to individual efforts, Canadians are increasingly participating in the environmental decision-making process. The movement toward more open decision making in resource and environmental management has occurred over the last few decades. Today, there is broad agreement that public consultation is a necessary part of decision-making.

Public consultation has taken many forms. Following are three ways in which the public (represented by various stakeholder groups) has been brought into the environmental decision-making process.

Co-management

Co-management is the sharing of power and responsibility between governments and local resource users. This arrangement can be formal or informal, but to some extent, users and other stakeholders take an active part in designing and enforcing management regulations, shared decision-making responsibilities and the sharing of information. Such arrangements have most often been developed in fisheries and forest resource management where there are many competing interest groups and where natural resources are vulnerable to depletion (Table 7.5.9).

Table 7.5.9
Examples of Public Participation through Consultation

Co-management agreements	Starting year	Resources covered	Location
James Bay and Northern Quebec Agreement on hunting, fishing and trapping (Chisasibi Cree fishery[1])	1975	all marine and terrestrial species	James Bay and northern Quebec
Northern Flood Agreement, Wildlife Advisory and Planning Board	1979	all aquatic and terrestrial species	resource areas of Cross Lake, Norway House, Nelson House and York Landing, Manitoba
Beverly and Kaminuriak Caribou Management Regime	1982	Beverly and Kaminuriak caribou herds	central Arctic and west Hudson Bay
Whiteshell Wild Rice Management Agreement	1983	wild rice	Whiteshell Provincial Park, southeast Manitoba
Beluga Management Strategy	1986	belugas of eastern James Bay, Hudson Strait and Ungava Bay	northern Quebec
Nunavut Wildlife Management Board	1992	all marine and terrestrial species	Nunavut Settlement Area, eastern Arctic
Nelson River Sturgeon Management Agreement	1992	sturgeon	Nelson River and tributary sturgeon spawning streams, Manitoba
Split Lake Cree Resource Management Board	1992	all aquatic and terrestrial species	resource area corresponding to the registered trapline district of the Split Lake Cree Nation, Manitoba

Note:
1. The Chisasibi Cree fishery in James Bay and northern Quebec is one example of resource management. In 1975, the Quebec and federal governments signed the James Bay and Northern Quebec Agreement, formally acknowledging the role of Cree leaders in management of fish and wildlife resources. Their role is to manage information, provide leadership for collective decision making and enforce the rules developed.
Source:
Berkes, F. and H. Fast, 1996, "Aboriginal Peoples: The basis for policy-making toward sustainable development." In Anne Dale and John B. Robinson (eds.), *Achieving Sustainable Development*, University of British Columbia Press, Vancouver.

National Round Table on the Environment and the Economy

The National Round Table on the Environment and the Economy (NRTEE) is an independent federal government agency that provides decision makers with information on the state of the environment and the economy. Appointed by order-in-council, NRTEE members are Canadians representing business, labour, academia, environmental organizations and First Nations.

The NRTEE was established in 1994 to assist in identifying, explaining and promoting the principles and practices of sustainable development. NRTEE activities are organized into a series of programs, each overseen by a task force or committee (Table 7.5.10).

Public participation in environmental assessment

Public participation in environmental assessment is usually possible through the approval and assessment of processes established by legislation (see section 7.1–**Environmental legislation and non-regulatory initiatives**). Often, these processes result in proceedings before administrative tribunals rather than courts. In many situations, public meetings are held to obtain public input on a proposed project.

The *Canadian Environmental Protection Act* (CEPA) states that the federal Minister of Environment may consult with any interested person and can work jointly with the representatives of different sectors interested in protecting the environment.

7.5.4 Public participation as conflict

In some cases, Canadians are motivated to participate in environmental issues through protest. In the 1980s and 1990s, organized environmental protest occurred over many environmental issues, including nuclear energy, waste management, noise pollution, land use (parks), fisheries and logging.

Table 7.5.10
National Round Table on the Environment and the Economy (NRTEE)

Program	Topic
National Forum on Climate Change	air
Greenhouse Gases Emissions Trading Program	air
Economic Instruments and Green Budget Reform	fiscal policy and taxes
Measuring Eco-Efficiency	natural resources, energy
Foreign Policy and Sustainable Development	sustainable development
Sustainable Transportation	impact on air quality
Aboriginal Communities and Resources Development	land

Source:
National Round Table on the Environment and the Economy, <http://www.nrtee-trnee.ca/home.html>, (accessed October 10, 1998).

7.6 Recreation

Canada's natural environment entices millions of Canadians and foreign visitors to spend their leisure time outdoors, be it for a hike in the woods or a whale-watching tour. While it is difficult to measure the value of these recreational experiences, they undoubtedly contribute to the quality of life in Canada.

The ways in which the environment is used for recreation are constantly changing, reflecting the continuous evolution of public tastes and values. New activities emerge while others fall in popularity. Traditional outdoor activities such as sightseeing and picnicking continue to be popular in Canada, but increasing numbers of people are turning to activities that offer adventure, discovery and stimulation in relatively unspoiled natural areas.

7.6.1 Participation in nature-related activities[1]

According to the Survey on the Importance of Nature to Canadians,[2] Canadians commit large amounts of their leisure time to activities that depend on natural areas and wildlife. In 1996, close to 20 million Canadians (85% of the population aged 15 and over) participated in at least one nature-related activity in Canada (Text Box 7.6.1). This amounted to 191 million same-day and overnight trips (Table 7.6.1). As Table 7.6.2 shows, the popularity of these activities was high in all parts of the country.

1. All information for this section is taken from Environment Canada, 1999, *The Importance of Nature to Canadians: Survey Highlights,* Catalogue No. En47-311/1999E, Ottawa.
2. In the Survey on the Importance of Nature to Canadians, approximately 87 000 Canadians aged 15 years and over were asked to provide information on the time and money that they devoted to nature-related activities in Canada in 1996. Residents of the Northwest Territories were not included in the survey.

Text Box 7.6.1
Defining Nature-related Activities

A nature-related activity is defined by the Survey on the Importance of Nature to Canadians as "a recreational activity that includes, in some form, either direct or indirect contact with nature." It is divided into six types of activities:

1. **Outdoor activities in natural areas**: Seventeen specified recreational activities (Table 7.6.4) take place on trips to natural areas such as forests, bodies of water, wetlands, open fields, scrublands and caves.
2. **Residential wildlife-related activities**: These activities take place around the residence and involve the watching, photographing, feeding or studying of wildlife, or the maintaining of shrubs, plants or birdhouses for wildlife.
3. **Wildlife viewing**: These activities, done on trips taken for the purpose of enjoying wildlife and natural areas, include watching, photographing, feeding and studying wildlife.
4. **Recreational fishing**: This involves catching or attempting to catch fish for non-commercial purposes.
5. **Hunting**: Activities here include searching for, pursuing, stalking, trailing or lying in wait for game that may or may not be harvested.
6. **Indirect nature-related activities**: These activities allow the participant to experience nature indirectly. They include reading about nature; watching films or television programs about nature; purchasing art, crafts or posters of nature; visiting zoos, game farms, aquariums or natural history museums; joining or contributing to naturalist, conservation or sportsmen's clubs; and maintaining, restoring or purchasing land for conservation.

Source:
Environment Canada, 1999, *The Importance of Nature to Canadians: Survey Highlights,* Catalogue No. En47-311/1999E, Ottawa.

Table 7.6.1
Numbers of Days and Trips on which Participants Engaged in Nature-related Activities, 1996

Activity	Days[1] engaged in activity		Trips[2] taken to participate in activity	
	Total	Per participant	Total	Per participant
	million days	days	million trips	trips
Outdoor activities in natural areas	166.0	16.1	137.1	13.3
Residential wildlife-related activities	1 265.0	140.1	...	...
Wildlife viewing[3]	77.4	17.6	55.0	12.5
Recreational fishing[3]	72.0	17.2	52.4	12.5
Hunting[3]	20.2	16.9	15.1	12.7
Indirect nature-related activities	...	...	...	...
All nature-related activities[4]	**1 492.8**	**100.8**	**191.0**	**16.6**

Notes:
Participant refers to Canadians 15 years of age and over, does not include residents of the Northwest Territories, and covers only activities that took place in Canada.
1. One day is defined as any part or all of a calendar day.
2. Includes same-day and overnight trips.
3. Includes those who reported this activity as either the main or the secondary reason for their trips.
4. Does not equal sum of rows since participants often took part in more than one type of nature-related activity during a particular day or trip.
Source:
Environment Canada, 1999, *The Importance of Nature to Canadians: Survey Highlights,* Catalogue No. En47-311/1999E, Ottawa.

Table 7.6.2
Participation in Nature-related Activities by Province and Territory of Residence, 1996

Province/ Territory	Outdoor activities in natural areas		Residential wildlife-related activities		Wildlife viewing[1]		Recreational fishing[1]		Hunting[1]		Indirect nature-related activities		All nature-related activities[2]	
	thousand persons	%	thousand persons	%	thousand persons	%	thousand persons	%	thousand persons	%	thousand persons	%	thousand persons	%
Nfld.	206	45.6	166	36.8	78	17.3	138	30.6	68	15.1	319	70.8	373	82.7
P.E.I.	40	37.6	57	53.1	13	12.2	13	12.5	4	3.5	77	71.8	91	85.0
N.S.	326	44.0	366	49.5	130	17.6	110	14.9	60	8.1	546	73.8	630	85.2
N.B.	266	44.1	276	45.9	115	19.0	103	17.0	79	13.1	427	70.9	502	83.3
Que.	2 281	38.6	1 709	28.9	1 174	19.9	1 037	17.6	394	6.7	4 369	74.0	4 900	83.5
Ont.	3 878	43.4	3 822	42.8	1 561	17.5	1 536	17.2	314	3.5	6 599	73.9	7 600	84.8
Man.	405	47.1	320	37.3	163	19.0	170	19.8	42	4.9	678	78.9	751	87.4
Sask.	346	45.6	273	36.1	115	15.1	171	22.6	47	6.2	562	74.2	648	85.6
Alta.	1 079	50.5	779	36.4	397	18.6	361	16.9	84	3.9	1 728	80.9	1 900	88.9
B.C.	1 460	47.5	1 253	40.8	639	20.8	537	17.5	98	3.2	2 244	73.0	2 500	82.2
Y.T.	9	45.3	8	41.3	6	27.9	6	32.2	2	11.0	11	57.6	15	76.9
Total[3]	**10 296**	**43.7**	**9 030**	**38.3**	**4 390**	**18.6**	**4 184**	**17.7**	**1 191**	**5.1**	**17 562**	**74.5**	**19 900**	**84.6**

Notes:
Figures may not add up due to rounding.
Participant refers to Canadians 15 years of age and over, does not include residents of the Northwest Territories, and covers only activities that took place in Canada.
1. Includes those who reported this activity as either the main or the secondary reason for their trips.
2. Does not equal sum of previous columns since participants often took part in more than one type of nature-related activity during the year.
3. Participants as a percentage of provincial/territorial population 15 years of age and over.
Source:
Environment Canada, 1999, *The Importance of Nature to Canadians: Survey Highlights*, Catalogue No. En47-311/1999E, Ottawa.

In total, Canadians spent close to $11 billion while taking part in nature-related activities. This included $6 billion for trip-related expenses such as transportation, accommodation and food; $3.1 billion for special equipment; and $1.8 billion for other items—such as entry fees, memberships and bird feed—needed to pursue these activities. Participants from Ontario, the Yukon and the four western provinces spent more than the national average, with the highest average expenditures recorded by participants from British Columbia and the Yukon Territory (Table 7.6.3).

Table 7.6.3
Expenditures on Nature-related Activities by Province and Territory of Residence, 1996

Province/Territory	Expenditures[1] Total	Per participant
	million dollars	dollars
Newfoundland	194	519
Prince Edward Island	25	271
Nova Scotia	245	389
New Brunswick	208	415
Quebec	2 061	418
Ontario	4 283	566
Manitoba	428	569
Saskatchewan	388	598
Alberta	1 171	616
British Columbia	1 938	767
Yukon Territory	16	1 052
Total	**10 956**	**549**

Note:
1. Refers to expenditures by Canadians 15 years of age and over, does not include residents of the Northwest Territories, and covers only activities that took place in Canada.
Source:
Environment Canada, 1999, *The Importance of Nature to Canadians: Survey Highlights*, Catalogue No. En47-311/1999E, Ottawa.

Outdoor activities in natural areas

In 1996, 10.3 million Canadians went to natural areas to take part in one or more of 17 outdoor activities. Relaxing outdoors, sightseeing, picnicking and swimming/beach activities were the most popular of these activities in almost every province (Table 7.6.4).

Regionally, outdoor activities in natural areas were most popular among residents of Alberta and British Columbia. Canadians between the ages of 25 and 44 were most likely to participate in one or more of these activities. Rates of participation between residents of urban and rural areas were identical.

In most cases, participants went to natural areas in their own province or territory to take part in these activities. Only about one out of every six participants took part in these activities outside of their home province. Some 57% of all participants reported that their main reason for visiting national or provincial parks or other protected areas was to take part in outdoor activities.

Residential wildlife-related activities

Nine million Canadians pursue nature-related activities regularly and inexpensively without travelling from home. In 1996, residential wildlife-related activities accounted for 80% of days spent by Canadians on all nature-related activities. Rates of participation were higher than the national average in the Maritimes, in rural areas, and among Canadians between the ages of 35 and 64.

Table 7.6.4
Participation in Outdoor Activities in Natural Areas by Province and Territory of Residence, 1996

Outdoor activity	Nfld.	P.E.I.	N.S.	N.B.	Que.	Ont.	Man.	Sask.	Alta.	B.C.	Y.T.	Total
						percent						
Relaxing in an outdoor setting	34.4	28.1	34.0	32.0	24.2	32.7	39.5	37.0	41.9	36.8	32.9	32.4
Sightseeing in natural areas	29.1	23.0	30.8	30.1	29.3	29.6	31.8	30.8	37.7	35.1	37.0	31.1
Picnicking	26.3	21.5	26.0	25.5	22.2	25.7	26.8	28.1	31.4	30.0	31.9	26.0
Swimming/beach activity	24.1	27.0	27.5	23.0	16.4	26.1	32.2	28.8	22.7	26.6	16.7	23.7
Camping	24.2	15.8	19.9	19.9	12.4	17.3	22.7	25.9	29.7	24.0	31.4	18.8
Hiking/backpacking	17.2	11.6	17.3	16.5	17.1	16.8	18.1	15.7	25.7	23.4	26.1	18.5
Photographing in natural areas	16.1	10.4	15.7	13.9	11.6	15.8	17.3	15.5	22.4	20.1	25.8	15.9
Gathering nuts, berries, firewood	20.2	10.2	12.4	12.6	9.3	10.2	13.2	15.0	13.7	11.1	13.5	11.0
Canoeing, kayaking, sailing	9.0	5.2	10.2	10.2	8.6	11.4	10.1	9.3	8.6	9.3	10.3	9.9
Powerboating	7.4	4.3	4.8	5.5	6.5	10.1	14.4	16.7	9.5	10.7	10.4	9.3
Cycling in natural areas	3.4	4.6	5.2	7.3	10.8	7.5	10.7	9.1	9.7	8.5	7.8	8.6
Downhill skiing	2.1	2.5	2.8	2.3	5.7	3.7	2.9	3.6	6.8	6.2	3.6[1]	4.7
Climbing	4.2	2.3	4.2	3.5	1.2	4.3	5.2	4.0	7.4	6.7	10.0	4.3
Cross-country skiing/snowshoeing	3.6	2.5	1.6	2.8	5.6	2.8	3.4	1.9	3.0	2.9	5.8	3.5
Off-road vehicle use	7.0	1.9	4.3	5.2	3.9	2.3	3.1	2.7	4.2	4.5	4.0	3.4
Snowmobiling	10.4	1.6[1]	1.3	3.3	2.7	2.4	4.1	3.2	2.3	1.0	5.1	2.5
Horseback riding	2.4	2.3	1.7	1.0	0.9	1.3	2.1	3.3	3.8	2.0	3.0[1]	1.6

Notes:
Participant refers to Canadians 15 years of age and over, does not include residents of the Northwest Territories, and covers only activities that took place in Canada.
1. High sampling variability due to sample size. Caution should be used when interpreting these figures.
Source:
Environment Canada, 1999, *The Importance of Nature to Canadians: Survey Highlights*, Catalogue No. En47-311/1999E, Ottawa.

Nine out of 10 of those who participated in wildlife-related activities around their home observed or cared for birds such as robins, sparrows and cardinals. Smaller proportions observed or cared for small mammals such as squirrels (57%), waterfowl such as ducks and geese (27%), large mammals such as deer (19%), and other wildlife such as butterflies and frogs (20%).

Wildlife viewing

In 1996, an estimated 4.4 million Canadians participated in wildlife viewing in Canada. Most often, wildlife viewing was a secondary part of trips where one of the outdoor activities shown in Table 7.6.4 was the main activity.

Those who made trips to view wildlife were typically younger than those who observed wildlife around their homes. Wildlife viewing was most popular with Canadians aged 25 to 44 and among residents of the Yukon Territory.

Recreational fishing

In 1996, 4.2 million Canadians fished recreationally in Canada. Recreational fishing was most popular among men, rural residents and Canadians younger than 45 years of age. The Yukon Territory and Newfoundland had participation rates much higher than the national average.

Freshwater fishing was more popular than saltwater fishing. Among those who made trips where fishing was the main activity, 96% fished in freshwater lakes, rivers or streams, while 6% fished in the Pacific Ocean and 4% in the Atlantic Ocean.[1]

Hunting

About 1.2 million Canadians hunted wildlife in Canada in 1996. One million of these made trips where hunting was the main activity. A higher-than-average proportion of these participants were from rural areas, and 9 out of 10 were male.

Big game animals—such as moose, caribou, bear and deer—were the most popular and most elusive target among recreational hunters. Less than half (42%) of those who hunted for big game were successful in harvesting wildlife, compared with 62% of those who hunted small mammals, 64% of those who hunted waterfowl and 69% of those who hunted birds other than waterfowl.

Indirect nature-related activities

For many Canadians, an interest in nature translates into time spent on activities that do not involve direct contact with nature, such as reading nature magazines or watching shows about nature on television (Table 7.6.5). Of all nature-related activities, indirect nature-related activities were pursued by the largest number of Canadians, with 17.6 million participants in 1996. Rates of participation were highest in Alberta and Manitoba, and lowest in the Yukon Territory. These activities were also more popular among men, rural residents and those over the age of 35.

1. Numbers do not add up to 100% since some participants fished in more than one of these locations.

Table 7.6.5
Participation in Indirect Nature-related Activities, 1996

Activity	Canadians participating[1]
	percent
Watching films or TV about nature	70
Reading about nature	43
Visiting a zoo, game farm, aquarium or museum of natural history	29
Purchasing art, crafts or posters of nature	17
Belonging or contributing to a nature-related organization	5
Maintaining, restoring or purchasing land for conservation	3
Any indirect nature-related activity	75

Note:
1. Refers to participation by Canadians 15 years of age and over and does not include residents of the Northwest Territories.
Source:
Environment Canada, 1999, *The Importance of Nature to Canadians: Survey Highlights*, Catalogue No. En47-311/1999E, Ottawa.

7.6.2 Nature recreation areas

Canadians live in a country that offers an abundance of natural areas, coastline, fresh water, forests and wildlife. Home to only 0.5% of the world's population, Canada occupies 7% of the world's land mass and contains 20% of the world's remaining wilderness.[1] Beginning with the establishment of Banff National Park in 1885, governments have sought to both promote and protect wilderness by setting aside large tracts of natural areas in the form of national parks, provincial parks and conservation areas.[2]

Nature parks

According to Statistics Canada's Survey of Heritage Institutions, 'nature parks' are defined as not-for-profit parks and conservation areas that have educational or interpretation programs for visitors. Most are government-run. The list of 172 nature parks in the survey consists of the majority of Canada's national parks and park reserves, as well as provincial parks, conservation areas and wildlife sanctuaries. During the 1995–96 fiscal year, attendance at these nature parks by Canadian and foreign visitors reached an all-time high of 58.5 million visits, surpassing the previous peak of 56.8 million in 1989–90.[3]

National parks

Canada's national parks are home to some of the country's most spectacular scenery, flora and fauna. As of 1997, the system included 38 national parks and park reserves, occupying about 2.3% of Canada's land mass. In addition, agreements had been reached for three marine conservation areas (Table 7.6.6).

From 1993 to 1996, the number of person-visits[4] made to all national parks ranged from 14.3 million to 15.3 million per year. Alberta is home to Canada's two most popular national parks, Banff and Jasper, which accommodate more than one-third of the total person-visits each year.

The Trans Canada Trail

The Trans Canada Trail, a recreation trail that will wind its way through every province and territory when completed, originated from the celebration of Canada's 125th birthday in 1992. It will be the largest trail of its kind in the world, stretching approximately 16 000 kilometres. The main east–west trunk will be about 14 200 kilometres in length and will connect most of Canada's major population centres, as well as hundreds of communities in between. This shared-use trail will accommodate five core activities: walking, cycling, horseback riding, cross-country skiing and snowmobiling. Approximately 75% of the trail will be built on existing trails, abandoned railway lines and Crown lands, with the remaining 25% being new trail.

As of November 1999, more than $6 million in donations had been received and about 8 000 kilometres of the trail were completed (Table 7.6.7). Individual Canadians were the source of 65% of the total donations received, corporations of 30%, and governments of 5%. The year 2000 is the target date for completion of the main trunk.

7.6.3 Ecotourism and adventure travel

According to the World Tourism Organization, tourism was the world's largest industry in 1996, and one of the fastest-growing throughout the 1990s.[5] Within the tourism industry, ecotourism and adventure travel are widely regarded as the fastest-growing segment. As these concepts are somewhat new and loosely defined (Text Box 7.6.2), reliable nationwide data on their size and growth in Canada are not available. There is, however, a large body of anecdotal evidence attesting to their growth. Increased interest in pursuing recreation activities in natural areas has potentially negative consequences for the environment, as well as for the recreationists themselves.

Natural sites have limited carrying capacities. The ecological carrying capacity is reduced when visitor activities begin to degrade the ecosystem (e.g., by disrupting wildlife and eroding soil). The aesthetic or social carrying capacity is reached when tourists encounter so many

1. Statistics Canada, 1997, *Canada's Culture, Heritage and Identity: a Statistical Perspective*, Catalogue No. 87-211-XPB, Ottawa.
2. For more information on parks and conservation areas, see section 6.7–**Protected areas**.
3. Statistics Canada, *op. cit.*

4. A person-visit is recorded each time a person enters a park reporting unit for the purpose of recreation. Same-day re-entries and re-entries by visitors staying overnight in the reporting unit do not constitute new person-visits.
5. World Tourism Organization, *What we offer?* <http://www.world-tourism.org/Offer.htm>, (accessed May 27, 1999).

Table 7.6.6
Characteristics of Canada's National Parks System, 1997

National park/National park reserve	Number of visitors	Area	Visitors per park area	Trails	Length of trails	Stress reported from visitor/tourism facilities[2]
	person-visits[1]	km^2	person-visits/km^2	number	kilometres	
Gros Morne, Nfld.	120 943	1 805.0	61	19	74	yes
Terra Nova, Nfld.	232 616	399.9	500	26	79	yes
Prince Edward Island, P.E.I.	749 212[3]	21.5	30 233	15	42	yes
Cape Breton Highlands, N.S.	379 894[(e)]	948.0	559	35	217	yes
Kejimkujik, N.S.	56 592	403.7	421	42	144	yes
Fundy, N.B.	220 725	205.9	1 068	26	111	yes
Kouchibouguac, N.B.	229 562	239.2	711	15	93	yes
Forillon, Que.	173 914	240.4	749	15	83	yes
Mauricie, Que.	215 888	536.1	504	81	67	yes
Mingan Archipelago, Que. (R)	19 860	150.7	186	8	4	no
Saguenay-St. Lawrence, Que. (M)	377 382	1 138.0	...	2	1	..
Bruce Peninsula, Ont.	207 444	154.0	714	8	12	yes
Fathom Five, Ont. (M)	399 054	113.0	...	...	...	..
Georgian Bay Islands, Ont.	69 252	25.6	1 992	15	51	yes
Point Pelee, Ont.	384 682	15.0	28 661	17	29	yes
Pukaskwa, Ont.	7 940	1 877.8	9	5	66	yes
St. Lawrence Islands, Ont.	63 278	8.7	5 057	7	9	yes
Riding Mountain, Man.	353 134	2 973.1	118	48	673	no
Wapusk, Man.	..	11 475.0	..	..	..	no
Grasslands, Sask.	3 451	906.4	2	3	13	yes
Prince Albert, Sask.	172 194	3 874.3	49	35	381	yes
Banff, Alta.	4 453 021	6 641.0	599	154	1 215	yes
Elk Island, Alta.	152 852	194.0	1 495	13	86	yes
Jasper, Alta.	2 100 089	10 878.0	120	109	1 772	yes
Waterton Lakes, Alta.	330 939	505.0	693	33	211	yes
Glacier, B.C.	101 924	1 349.3	119	51[4]	201[4]	no
Gwaii Haanas B.C. (R,M)	2 077	1 495.0[5]	1	..	..	yes
Kootenay, B.C.	1 113 795	1 406.4	853	39	261	yes
Mount Revelstoke, B.C.	163 687	259.7	616	51[4]	201[4]	no
Pacific Rim, B.C. (R)	836 120	285.8[5]	1 241	21	339	yes
Yoho, B.C.	678 189	1 313.1	495	71	266	no
Ivvavik, Y.T.	152	9 750.0	--	..	..	no
Kluane, Y.T.	69 924	22 013.3	3	18	235	no
Vuntut, Y.T.	..	4 345.0	..	..	..	no
Aulavik, N.W.T.	20	12 200.0	--	..	..	no
Auyittuq, N.W.T. (R)	470	19 707.4[6]	--	1	100	no
Ellesmere Island, N.W.T. (R)	462	37 775.0	--	..	..	no
Nahanni, N.W.T. (R)	4 605	4 765.2	--	4	12	no
Tuktut Nogait, N.W.T.	..	16 340.0	..	..	..	..
Wood Buffalo, N.W.T. and Alta.	6 040	44 802.0	--	10	67	yes
Total	**14 451 383**	**222 283.0**[7]	..	...	...	...

Notes:
(e) Estimated data.
(R) National park reserve: an area set aside as a national park pending settlement of any outstanding Aboriginal land claim.
(M) Marine conservation area.
1. Considered to be each time a person enters a park reporting unit for the purpose of recreation. Same-day re-entries and re-entries by visitors staying overnight in the reporting unit do not constitute new person-visits.
2. Stress from visitor/tourism facilities was reported if: 1) it had a definite ecological impact; 2) the scale of the impact was greater than 1 km^2; and 3) the trend in the intensity of the stress was either increasing or stable.
3. Excludes visits to Green Gables House.
4. Combined total of Glacier and Mount Revelstoke national parks.
5. Excludes marine portion.
6. Park area measurement pending review by Surveyor General.
7. Excludes Fathom Five and Saguenay-St. Lawrence Marine Conservation areas, as well as marine portions of Gwaii Haanas (3 570 km^2) and Pacific Rim Park (214 km^2) reserves.
Source:
Parks Canada, 1998, *State of the Parks, 1997 Report*, Ottawa.

Table 7.6.7
Status of the Trans Canada Trail, November 1999

Province/Territory	Target length	Completed length	Proportion of goal achieved
	kilometres		percent
Newfoundland	900	885	98
Prince Edward Island	350	350	100
Nova Scotia	600	417	70
New Brunswick	700	630	90
Quebec	1 200	870	73
Ontario	3 400	1 369	40
Manitoba	900	803	89
Saskatchewan	1 400	400	29
Alberta	2 000	243	12
British Columbia	2 700	890	33
Yukon Territory	1 500	651	43
Northwest Territories	586	586	100
Canada	**16 236**	**8 094**	**50**

Source:
Trans Canada Trail Foundation. <http://www.tctrail.ca/>, (accessed January 14, 2000).

others, or the impacts of others, that their recreational experience is diminished. Few of these impacts can be quantified at the national scale as most are particular to activities at or near specific sites. There is evidence, however, that carrying capacities are being exceeded in many sites. In Canada's national parks, tourism and visitor facilities were the most commonly reported stressors causing significant ecological impacts (Table 7.6.6).

One response by Parks Canada to preserve the ecological integrity of certain areas has been to impose limits on numbers of participants in recreation activities. For example, the following restrictions have been imposed or proposed:

- Pacific Rim National Park, B.C.: only 60 hikers a day may begin hiking the West Coast Trail;[1]
- Chilkoot Trail National Historic Site, B.C.: only 50 backcountry permits are issued daily;[2]
- Gwaii Haanas National Park Reserve, B.C.: groups of no more than 12 people may travel together in the park, and 'Gwaii Haanas Watchmen' regulate the number of visitors that may venture onto sites of old Haida villages;[3]
- Point Pelee National Park, Ont.: a maximum of 1 100 cars can enter the park at a given time—the only such cap in the national parks system;[4] and
- Banff National Park, Alta.: guidelines have been drafted to cap the number of skiers at Banff's four ski resorts and to ban any development that would attract more skiers to sites where the maximum number has been reached.[5]

1. Nanao Kachi, Parks Canada, personal communication.
2. *Ibid.*
3. Ron Hamilton, Gwaii Haanas National Park Reserve, personal communication.
4. Dan Reive, Point Pelee National Park, personal communication.

Text Box 7.6.2
Ecotourism and Adventure Travel

'Ecotourism' is a relatively new term applied to travel activities that, in general, are based on the ecology of a particular site. While a variety of definitions exists, ecotourism in the Canadian context has been defined as "enlightening nature travel experiences that contribute to the conservation of the ecosystem while respecting the integrity of the host community."[1] Popular ecotourism activities include hiking, birdwatching, nature photography, wildlife viewing and botanical study. Broader definitions encompass activities that are also commonly associated with nature-based 'adventure travel,' such as mountain climbing, kayaking and dogsledding. Activities that are based on an interest in local cultures, such as participation in native rituals or on archaeological digs, are also commonly associated with both categories.

1. Canadian Environmental Advisory Council, 1992, *Ecotourism in Canada*, Catalogue No. En92-15/1992E, Ottawa, p. 14.

The growing number of recreationists seeking backcountry adventures also translates into increased numbers at risk from natural hazards. Before 1950, victims of avalanche accidents were primarily people working in or driving through avalanche-prone areas. Today, most of those killed by avalanches are backcountry skiers followed by snowmobilers—whose numbers have increased dramatically in recent years (Table 7.6.8). Between 1992 and 1996, more snowmobilers fell victim to avalanches than in the 14 years prior. The majority of fatal avalanches are triggered by the victims themselves.

Table 7.6.8
Avalanche Fatalities by Activity, 1984-1996

Activity	Proportion of all avalanche fatalities[1]
	percent
Backcountry skiing	43
Snowmobiling	20
Mountaineering	14
Ice climbing	7
Out of bounds	7
Snowshoeing and hiking	3
Other recreation	3
Inside building	3

Note:
1. Figures based on the 114 avalanche fatalities in Canada between October 1984 and September 1996.
Source:
Canadian Avalanche Association, *Trends and Patterns in Avalanche Accidents.* <http://www.avalanche.ca/Accidents%20Chapter%202.htm>, (accessed April 14, 1999)

5. Seskus, Tony, 1999, "New rules restrict Banff skiers," *The Ottawa Citizen*, April 27, p. A3.

7.7 Environmental education

Education promotes a population's environmental literacy, providing the "keys to the knowledge, skills, and values that individuals need in order to make direct connections between everyday activities and major environmental issues."[1] The public obtains environmental information from several sources, including television, radio, the Internet, newspapers, magazines and publications such as this one (for more details, see section 7.5–**Public participation**). People can also learn about the environment through the formal education system.

Primary and secondary school

Until the end of Grade 12, the degree to which environmental studies are integrated into the educational system is determined primarily by set course curricula. One example of environmental education curricula in science programs is set out by the Council of Ministers of Education. This example provides insight into proposed levels of environmental education (Table 7.7.1 and Text Box 7.7.1).

Provinces must develop their own curricula beyond these general guidelines. In Ontario, for example, the Grade 9 Geography of Canada course incorporates several environmental elements, including the study of ecozones, and a theme devoted to human–environment interactions.[2]

The general learning outcomes for scientific knowledge in the common curriculum framework demonstrate a progression from a general descriptive knowledge of the environment to a more analytical knowledge of specific components by the end of Grade 12. Statistics Canada offers several resources that can be used to meet these learning goals (Text Box 7.7.2).

1. Environment Canada, 1996, *The State of Canada's Environment 1996*, Ottawa, p. 2–21.

2. Ontario Ministry of Education and Training, *The Ontario Curriculum Grades 9 and 10: Canadian and World Studies, 1999*, <http://www.edu.gov.on.ca/eng/document/curricul/curricul.html>, (accessed April 14, 1999).

Table 7.7.1
Selected Science Learning Outcomes, Kindergarten to Grade 12

Education level		Expected learning outcomes
Kindergarten to Grade 6		describe and compare characteristics and properties of living things, objects and materials
		describe and predict causes, effects and patterns related to change in living and non-living things
		describe interactions within natural systems and the elements required to maintain these systems
		describe forces, motion and energy and relate them to phenomena in their observable environment
Grade 7 to Grade 9	Life science	
		explain and compare processes that are responsible for the maintenance of an organism's life
		explain processes responsible for the continuity and diversity of life
		describe interactions and explain dynamic equilibrium within ecological systems
	Physical science	
		describe the properties and components of matter and explain interactions between those components
		describe the properties of energy and explain energy transfers and transformations
		recognize that many phenomena are caused by forces and explore various situations involving forces
	Earth and space science	
		explain how the earth provides both a habitat for life and a resource for society
		explain patterns of change and their effects on the earth
Grade 10 to Grade 12	Life science	
		compare and contrast the reproduction and development of representative organisms
		determine how cells use matter and energy to maintain organization necessary for life
		demonstrate an understanding of the structure and function of genetic material
		analyse the patterns and products of evolution
		compare and contrast mechanisms used by organisms to maintain homeostasis
		evaluate relationships that affect the biodiversity and sustainability of life within the biosphere
	Chemistry	
		identify and explain the diversity of organic compounds and their impact on the environment
	Physics	
		analyse interactions within systems using the laws of conservation of energy and momentum
		explain the fundamental forces of nature using the characteristics of gravitational, electric and magnetic fields
		analyse and describe different means of energy transmission and transformation
	Earth and space science	
		demonstrate an understanding of the nature and diversity of energy sources and matter in the universe
		describe and predict the nature and effects of changes to terrestrial systems
		demonstrate an understanding of the relationships among systems responsible for changes to the earth's surface

Source:
Council of Ministers of Education, Canada, 1997, *Common Framework of Science Learning Outcomes: K to 12*, CMEC Secretariat, Toronto, <http://www.cmec.ca/science/framework/index.htm>, (accessed June 8, 1999).

Text Box 7.7.1
Foundation Statements for Scientific Literacy in Canada

Foundation 1: Science, technology, society and the environment

Students will develop an understanding of the nature of science and technology, of the relationships between science and technology, and of the social and environmental contexts of science and technology.

Foundation 2: Skills

Students will develop the skills required for scientific and technological inquiry, for solving problems, for communicating scientific ideas and results, for working collaboratively, and for making informed decisions.

Foundation 3: Knowledge

Students will construct knowledge and understandings of concepts in life science, physical science, and earth and space science, and apply these understandings to interpret, integrate, and extend their knowledge.

Foundation 4: Attitudes

Students will be encouraged to develop attitudes that support the responsible acquisition and application of scientific and technological knowledge to the mutual benefit of self, society, and the environment.

Source:
Council of Ministers of Education, Canada, 1997, *Common Framework of Science Learning Outcomes: K to 12*, CMEC Secretariat, Toronto, <http://www.cmec.ca/science/framework/pages/english/table.html>, (accessed June 8, 1999).

Postsecondary education

Beyond high school, student choices for education become more career oriented. Individuals interested in careers related to the environment are likely to pursue additional education in environmental fields at the college and university levels. At this stage, a variety of institutions offer environmental training. Faculties of engineering, science, social science and agriculture provide environmentally oriented courses such as geography, biology, environmental science, environmental engineering, agricultural science and ecology. Beyond this are entire programs devoted specifically to environmental studies. It is, therefore, important to realize that not all postsecondary environmental education will be captured by an analysis of enrolment in specific environmental studies programs.

Text Box 7.7.2
Statistics Canada and Environmental Education

The Statistics Canada Web site <http://www.statcan.ca> offers a number of resources relevant to environmental education. These range from tabular data under the *Canadian statistics* heading, through lesson plans under *Education resources,* to downloadable publications under *Products and services*. Many of these resources are available free of charge.

Students can gain a practical understanding of how environmental statistics are collected and compiled by participating in the *Household Environment Survey* — School Edition <http://www.statcan.ca/english/kits/houenv.htm>. This activity allows students from across Canada to collect data on household environmental practices using the same questionnaire. They are then able to submit their results on-line and compare their data with those submitted from other schools.

For more information on these and other educational activities at Statistics Canada, please send an e-mail to <education@statcan.ca>.

The graduating class of 1990

The National Graduates Survey of 1990 gathered data that provide a snapshot of environmental education in Canada.[1]

Employment prospects

The majority (77%) of 1990 college graduates were able to find full-time employment within two years of graduation (Table 7.7.2). Students with diplomas in environmental and conservation technologies had a higher percentage of full-time employment in this period, but this declined to the average for all fields of study five years after graduation.

Almost three-quarters (74%) of 1990 university graduates were working full time two years after graduation (Table 7.7.2). As with the career and technical graduates, those with degrees in the field of man and environment had a higher rate of full-time employment than the average for all fields of study two years after graduation.

In college, a higher percentage of graduates of environmental and conservation technology graduates had a job related to their education two years after graduation when compared with the average for all other fields of study

1. This survey was conducted in 1992 by Statistics Canada in partnership with Human Resources Development Canada, and was augmented by a follow-up survey in 1995.

Table 7.7.2
Employment of 1990 Graduates from Selected Fields of Study, June 1992 and June 1995

Level and field of study	Working full time June 1992	June 1995
	percent	
Career and technical graduates		
Total (all fields of study)	77	78
Environmental and conservation technologies	85	78
i) Environmental control and protection technologies	89	82
ii) Land resources technologies	..	..
iii) Water science technologies	86	83
iv) Wildlife and forest conservation technologies	..	..
v) Other environmental and conservation technologies	86	86
University graduates		
Total (all fields of study)	74	80
Man and environment studies	80	80
i) Regional, rural, urban, city planning and community development	89	83
ii) Resource management, environmental studies	72	77

Source:
Human Resources Development Canada, Applied Research Branch.

Table 7.7.3
Relationship of Employment to Education of 1990 Graduates from Selected Fields of Study, June 1992 and June 1995

Level and field of study	Working in their field of study June 1992	June 1995
	percent	
Career and technical graduates		
Total (all fields of study)	51	43
Environmental and conservation technologies	55	38
University graduates		
Total (all fields of study)	41	35
Man and environment studies	30[1]	32[1]

Note:
1. Less reliable than other figures in the table (coefficient of variation between 16.6% and 25%).
Source:
Human Resources Development Canada, Applied Research Branch.

(Table 7.7.3). This percentage decreased dramatically five years after graduation. University graduates in man and environment studies were less likely to be employed in an occupation related directly to their field of study, compared with the average for all fields of study.

Was an environmental education a good choice in retrospect?

Approximately two-thirds of the college students graduating in 1990 with a career and technical diploma indicated they would take the same program of study if they had the choice to do it again (Table 7.7.4). The percentage was similar for environmental and conservation technologies graduates. Almost three-quarters of the 1990 university graduates surveyed were satisfied with their education choices, indicating they would select the same education program again. Satisfaction within the man and environment field was at a similar level.

Table 7.7.4
1990 Graduates from Selected Fields of Study Who Would Select the Same Program, June 1995

Level and field of study	Percent
Career and technical graduates	
Total (all fields of study)	67
Environmental and conservation technologies	69
i) Environmental control and protection technologies	64
ii) Land resources technologies	..
iii) Water science technologies	76
iv) Wildlife and forest conservation technologies	..
v) Other environmental and conservation technologies	76
University graduates	
Total (all fields of study)	73
Man and environment studies	72
i) Regional, rural, urban, city planning and community development	64
ii) Resource management, environmental studies	79

Source:
Human Resources Development Canada, Applied Research Branch.

Glossary

Italicized terms are defined or explained elsewhere in the Glossary.

Abiotic: Refers to all non-living elements of an *ecosystem*, including, for example, *climate*, soil, water, geology, physiography, ice, and non-living *organic matter* like *peat*.

Accessible forest land: Forest land that is accessible by road, rail or water for the purpose of harvesting wood, as classified within a forest inventory map sheet.

Acid deposition (includes acid rain and other forms of acidic precipitation): Refers to deposition of a variety of acidic pollutants (acids or acid-forming substances) on the earth's surface. Deposition can be in either wet forms (e.g., rain, fog or snow) or dry forms (e.g., dust particles).

Aerosols: 1) Small droplets or particles suspended in the *atmosphere*. They are emitted both naturally (e.g., in volcanic eruptions) and as the result of human activities such as burning *fossil fuels*. 2) The pressurized gas used to propel substances out of a container.

Age cohort: A group of individuals of the same age or belonging to the same age group.

Algae: Simple rootless plants that grow in sunlit waters in relative proportion to the amounts of nutrients available. They can affect water quality adversely by lowering the amount of dissolved oxygen in the water. They are food for fish and small aquatic animals.

Allelopathic: Refers to plants that inhibit the growth of other plants by secreting noxious or *toxic* chemicals. Black walnut is an example.

Ambient air: Any unconfined portion of the atmosphere; open air; surrounding air.

Anthropogenic: Refers to influences that originate from humans.

Antibiotic resistance: Occurs when micro-organisms gradually develop a tolerance to the chemicals designed to kill them.

Aquaculture: The marine or freshwater cultivation of finfish or *shellfish*.

Aquifer: An underground, water-bearing formation of porous stone, sand, etc. that yields significant quantities of water when tapped by a well.

ARET: Accelerated Reduction/Elimination of Toxics.

Aromatic hydrocarbons: A large group of cyclic *hydrocarbon* compounds composed of one or more six-carbon rings containing double bonds. The simplest aromatic hydrocarbon, *benzene*, consists of one six-carbon ring containing three double bonds with one hydrogen atom attached to each carbon atom. When they contain more than one six-carbon ring, these compounds are referred to as polycyclic aromatic hydrocarbons. The term 'aromatic' refers to the strong, not unpleasant odour that is characteristic of most compounds in this group. Some aromatic hydrocarbons are noted for their toxicity to animals and/or humans (Sax and Lewis 1987).

Atmosphere: The region of gases and *particulate* matter extending above the earth's surface (Miller 1985).

Atmospheric inversion: A climatic condition in which a layer of warm air lies above a layer of comparatively cooler air, thus reversing the normal thermal gradient where temperature decreases as elevation increases. Such events prevent the normal upward flow of air and can trap pollutants near the earth's surface. In a prolonged inversion, air *pollution* may rise to harmful levels (adapted from Miller 1985).

Bacteria: Smallest living organisms; with *fungi*, they comprise the decomposer level of the *food chain* (Miller 1985).

Benzene (C_6H_6): An *aromatic hydrocarbon* found in gasoline and automobile exhaust. It is *toxic* and carcinogenic.

Bioaccumulation: The gradual accumulation in organisms of foreign substances. It can be harmful in the case of *toxic* substances.

Biochemical oxygen demand (BOD): A measure of the amount of oxygen consumed in the biological processes that break down organic matter in water. The greater the BOD, the greater the degree of *pollution*. The standard measure is taken for five days at 20°C (BOD_5).

Biodiversity: The totality of genes, species and *ecosystems* in a region or the world.

Biomagnification: Cumulative increase in the concentration of a substance in successively higher levels of a *food web*.

Biomass: Quantity of living matter in a defined area, expressed in units of living or dead mass (Demayo and Watt 1993).

Biosphere: The portion of the earth and its *atmosphere* that can support life.

Biota: Collectively, the living organisms in a given *ecosystem*, including *bacteria* and other micro-organisms, plants and animals (Demayo and Watt 1993).

Biotic: Refers to the living elements of an *ecosystem*, such as plants and animals.

Bitumen: A high-sulphur, tarlike heavy oil extracted from tar sands and then upgraded to synthetic fuel oil (Miller 1985).

BOD: *Biochemical oxygen demand.*

Capital expenditures: Expenditures by business or government on machinery, equipment, buildings and other goods that have useful lives of more than one year. Expenditures on repairs to these goods are also included.

Carbon dioxide (CO_2)**:** One of the *greenhouse gases*, which is released to the *atmosphere* by both natural and human activities.

Carbon monoxide (CO): A colourless, odourless and poisonous gas released primarily by incomplete combustion of *fossil fuels* (especially by automobiles).

Carrying capacity: 1) In recreation management, the amount of use a recreation area can sustain without loss of quality. 2) In wildlife management, the maximum number of animals an area can support during a given period.

Catalytic converter: An air *pollution* abatement device that removes pollutants from motor vehicle exhaust, by either oxidizing them into *carbon dioxide* and water or reducing them to nitrogen.

Catchment area: The area from which rainfall flows into a river.

CCME: Canadian Council of Ministers of the Environment.

CEAA: Canadian Environmental Assessment Act.

CEPA: Canadian Environmental Protection Act.

Census Metropolitan Area (CMA)**:** An area composed of an urban core of at least 100 000 persons (based on the previous census), together with adjacent suburban and rural areas that have a high degree of economic and social integration with the urban core.

CFCs: *Chlorofluorocarbons.*

CH_4: *Methane.*

Chlordane: A man-made *organochlorine* commonly used as a household insecticide during the 1960s and 1970s. It is banned in Canada.

Chlorinated organic compounds: see *Organochlorine compounds.*

Chlorofluorocarbons (CFCs)**:** A family of inert, non-toxic and easily liquefied chemicals used in refrigeration, air conditioning, packaging and insulation, or as *solvents* and *aerosol* propellants. Because CFCs are not destroyed in the lower *atmosphere,* they drift into the upper atmosphere where their chlorine components destroy *ozone*. They are also strong *greenhouse gases.*

CITES: Convention on International Trade in Endangered Species of Wild Fauna and Flora.

CLI: Canada Land Inventory.

Climate: The average weather that occurs in a specific area over a fairly long period of time.

Climate change: An enduring alteration of *climate* bringing about corresponding changes to *ecosystems* and socio-economic activity.

CMA: *Census metropolitan area.*

CO: *Carbon monoxide.*

CO_2: *Carbon dioxide.*

Condensation: The process by which a vapour becomes a liquid or solid; the opposite of *evaporation*. In meteorological usage, this term is applied only to the transformation from vapour to liquid.

Contaminant: Any physical, chemical, biological or radiological substance that has an adverse effect on air, water, soil or *biota*.

COSEWIC: Committee on the Status of Endangered Wildlife in Canada.

Crop rotation: The practice of changing the crop planted on a given parcel of land from one cropping period to the next. A field may, for example, grow soybeans one year and corn the next. This is done to prevent the buildup of crop pests and to change the demands on the soil.

Current expenditures (by government)**:** All current outlays for goods and services by the government sector, covering wages and salaries of government employees and purchases of other non-capital goods and services.

DDT (Dichlorodiphenyltrichloroethane)**:** A chlorinated *hydrocarbon pesticide* that was once widely used. It is now banned from production and use in many countries because of its persistence in the environment and accumulation in the *food chain.*

Defoliation: The removal of leaves from vegetation.

Degree-days: Represent the number of Celsius degrees that the mean temperature is above or below a given base. Values above $5^{o}C$ are frequently called 'growing degree-days,' and are used in agriculture as an index of crop growth.

Desertification: The conversion of productive rangeland into desert through a combination of overgrazing and prolonged drought (Miller 1985).

Dioxins and furans: The popular names for classes of *organochlorine compounds* known as polychlorinated

dibenzo-*p*-dioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs), a few of which are highly *toxic*. Dioxins and furans are formed either as by-products during some types of chemical production that involve chlorine and high temperatures or during combustion where a source of chlorine is present (e.g., incinerators that burn trash containing chlorinated compounds, exhaust from diesel engines). Chlorine bleaching of kraft wood pulp is another source.

Drainage basin: The land area that drains into a stream, river, lake or ocean. An oceanic drainage basin is comprised of many *catchment areas*.

EA: Environmental assessment.

Ecolabelling: Special product labels that indicate that a product meets standards of environmental soundness that are supported by extensive research into the product's impact on the environment.

Ecological integrity: The degree to which an *ecosystem* has the ability to be self-sustaining over the long term.

Ecological processes: The actions or events that link organisms, including humans, and their environment, including production, decay, *nutrient cycling*, disturbance and successional development.

Economic growth: The increase of an economy's real output or income over time. It is frequently expressed as total or per capita G*ross Domestic Product* over a period of time.

Ecoprovince: A part of an *ecozone* characterized by major structural or surface forms, fauna realms, vegetation, soil, hydrology and macroclimate. There are 53 terrestrial ecoprovinces in Canada.

Ecosystem: A biological community of interacting organisms and their physical environment.

Ecotourism: Tourism that has as its focus nature-related, non-consumptive activities or experiences (e.g., bird-watching or whale-watching) and that helps people appreciate and understand *ecosystems* and their conservation.

Ecozone: An area of the earth's surface representative of large and very generalized ecological units characterized by interactive and adjusting *abiotic* and *biotic* factors. There are 15 terrestrial and 5 marine ecozones in Canada.

ECP: Environmental Choice Program.

Effluent: Treated or untreated wastewater that flows out of a treatment plant, sewer or industrial outfall. Generally refers to wastes discharged into *surface waters*.

El Niño: A warm ocean current from the tropics that intrudes each winter along the west coast of northern South America (Ricklefs 1990).

Emission trading: A system in which tradable permits issued by governments give companies or institutions the right to emit fixed quantities of certain (normally gaseous) pollutants; for example, permits might be issued for the right to emit sulphur dioxide. The number of permits issued is controlled so that the total amount of the pollutant released from all sources is kept below an acceptable threshold. Holders of permits are allowed to trade them with others, with the price being determined through the normal market forces of supply and demand.

Enteric pathogens: Disease-causing agents that infect the intestinal tract.

Environment: The components of the earth, including air, land and water, all layers of the *atmosphere*, all *organic* and inorganic matter and living organisms, and the interacting systems that include all of these components. Everything that surrounds and affects or influences an organism or a group of organisms; it includes both *biotic* and *abiotic* components as well as both natural and human-built elements.

Erosion: The wearing down or washing away of the soil and rocks by the action of water, wind or ice.

Estuary: Regions of interaction between rivers and nearshore ocean waters, where tidal action and river flow create a mixing of fresh and salt water. These areas may include bays, mouths of rivers, salt marshes and lagoons. These brackish water *ecosystems* shelter and feed marine life, birds and wildlife.

Eutrophication: The overnourishment of aquatic *ecosystems* with plant nutrients resulting from natural processes (e.g., *erosion*, run-off) and human activities (e.g., agriculture, urbanization, industrial discharge). These nutrients support large amounts of aquatic life that can deplete the oxygen supply in bodies of water (adapted from Miller 1985).

Evaporation: The process by which a liquid changes to a vapour.

Exotic: Refers to any organism that enters an *ecosystem* beyond its normal range through deliberate or inadvertent introduction by humans.

Fertility rate: The number of live births occurring in a given time period relative to the number of women of childbearing age.

Food chain: A hierarchy of organisms, each of which relies upon the next, lower member of the sequence as a food source.

Food web: The complex intermeshing of individual *food chains* in an *ecosystem*.

Fossil fuels: Buried deposits of decayed plants and animals that have been converted to crude oil, coal, natural gas or heavy oils by exposure to heat and pressure in the

earth's crust over hundreds of millions of years (Miller 1985).

Fragmentation: The disruption of extensive *habitats* into isolated and small patches (Meffe *et al.* 1994).

Fresh water: Water that generally contains less than 1 000 milligrams per litre of dissolved solids such as metals, nutrients, etc.

Fugitive emissions: Emissions of pollutants that cannot be prevented by normal *pollution* control measures. They occur either because of imperfections in the design or operation of machinery and equipment (e.g., *solvent* emissions that result from damaged or imperfect seals on chemical storage tanks) or as an inherent result of certain industrial processes (e.g., *methane* emissions from coal seams as a result of mining). Fugitive emissions are very difficult to control because their sources are numerous and widespread and each one may represent only a small portion of the total.

Fungus (Fungi)**:** Simple or complex organism without chlorophyll. The simpler forms are unicellular; the higher forms have branched filaments and complicated life cycles. Some are *pathogens*; others stabilize sewage and digest composted waste. Examples are molds, yeasts and mushrooms.

Furans: *Dioxins and furans.*

GCMs: *General circulation models* (also referred to as global climate models).

GDP: *Gross Domestic Product.*

General circulation models (*GCMs*)**:** Mathematical simulations of future climatic conditions using computer programs.

Geophysical event: A natural event that results in a physical change in the earth's surface (e.g., earthquakes, landslides and *erosion*).

GERD: Gross expenditure in research and development.

GERT: Greenhouse Gas Emission Reduction Trading.

GHG: *Greenhouse gas.*

Global warming: see *Greenhouse effect.*

Greenhouse effect: A natural phenomenon whereby certain trace atmospheric gases (referred to as *greenhouse gases*) absorb a portion of the heat radiating from the planet's surface, trapping and reflecting it back to the surface. Scientists have expressed concern that human-induced changes in the atmospheric greenhouse gas concentrations are significantly enhancing the naturally occurring greenhouse effect (Houghton *et al.* 1996). This enhancement is predicted to cause warming of the earth's *atmosphere* and significant disruptions in global climatic systems.

Greenhouse gases (GHGs)**:** The group of chemical compounds that are responsible for the so-called '*greenhouse effect.*' The most important greenhouse gases produced by economic activity are *carbon dioxide* (CO_2), *methane* (CH_4), nitrous oxide (N_2O) and *chlorofluorocarbons* (CFCs).

Gross Domestic Product (GDP)**:** A measure of the unduplicated value of goods and services produced within a nation's boundaries, regardless of the ownership of the factors of production.

Groundfish: Those species of fish that normally occur on or close to the seabed, such as cod and haddock. Also known as bottom fish.

Ground-level ozone: Ozone (O_3) that occurs near the surface of the earth. It is a pollutant of concern in *smog* because of its *toxic* effects (adapted from Arms 1990).

Groundwater: The supply of *fresh water* found beneath the earth's surface (usually in *aquifers*); often supplies wells and springs.

Habitat: Place where an animal or plant normally lives, often characterized by a dominant plant form or physical characteristic (e.g., the stream habitat, the forest habitat) (Ricklefs 1990).

Hazardous waste: Waste that poses a risk to human or ecological health and requires special disposal techniques to make it harmless or less dangerous.

HCs: *Hydrocarbons.*

HCFCs: *Hydrochlorofluorocarbons.*

Heavy metals: Metallic elements with atomic weights higher than sodium (e.g., *mercury*, chromium, cadmium, arsenic and lead); can damage living things at low concentrations and tend to accumulate in the *food chain*.

High-level radioactive waste (HLRW)**:** Waste generated in core fuel of a nuclear reactor, found at nuclear reactors or by nuclear fuel reprocessing. It is a serious threat to anyone who comes near the waste without shielding. (Compare *low-level radioactive waste.*)

HLRW: *High-level radioactive waste.*

Host: 1) In genetics, the organism, typically a *bacterium*, into which a gene from another organism is transplanted. 2) In biology, an animal or plant infected or parasitized by another organism.

Hydrocarbons (HCs)**:** A very large group of *organic compounds* consisting exclusively of hydrogen and carbon atoms. Hydrocarbons are grouped into two principal types: aliphatic hydrocarbons, in which the atoms are arranged in the form of a 'chain' (e.g., *methane*, ethane and propane); and cyclic hydrocarbons, in which the atoms are arranged in the form of rings of three or more carbon atoms (e.g., cyclohexane and *benzene*) (Sax and Lewis 1987). (See also *aromatic hydrocarbons.*)

Hydrochlorofluorocarbons (HCFCs): see *chlorofluorocarbons.*

Hydrologic cycle: The cycle of water from the *atmosphere* to the earth and back to the atmosphere through precipitation, infiltration, percolation, storage, *evaporation*, *transpiration* and *condensation* (Texas Environmental Center).

Incineration: The controlled process by which combustible wastes are burned and changed into gases and residual solid material.

Instream use: Water use taking place within a stream channel (e.g., hydro-electric power generation, navigation, fish propagation, recreation).

Ionizing radiation: High-energy *radiation* that can dislodge one or more electrons from atoms it hits to form charged particles called ions (Miller 1985).

IQUA: Index of the Quality of the Air.

ISO: International Organization for Standardization.

Isotopes: Two or more forms of a chemical element that have the same number of protons but different numbers of neutrons in their nuclei (Miller 1985).

IUCN: World Conservation Union (which still uses the acronym from its former name—International Union for the Conservation of Nature).

Joule: The *Système Internationale* standard unit of measure for energy. The energy content of a 40-litre tank of gasoline is about 1.36 billion joules.

Landfill: A land waste disposal site that is located with or without regard to possible *pollution* of *groundwater* and *surface water* from *run-off* and leaching. Waste is covered intermittently with a layer of earth to reduce scavenger, aesthetic, disease and air pollution problems (adapted from Miller 1985). Secure landfills accept only specified waste and have controls in place to monitor the types and quantities of waste that are placed in them.

LLRW: *Low-level radioactive waste.*

Low-level radioactive waste (LLRW)**:** All forms of *radioactive* wastes arising from 1) the activities leading to and including nuclear electricity generation; 2) nuclear research and development; and 3) the production and application of *radioisotopes* in medicine, education, research and industry. Not included is spent nuclear fuel waste (often referred to as *high-level radioactive waste*) from nuclear reactors, some types of radioactive materials, and waste from uranium mining and milling (including mill *tailings*).

Mercury (Hg): A heavy metal that can accumulate in the *environment* and is highly *toxic.*

Methane (CH_4)**:** A colourless, nonpoisonous, flammable gas created by anaerobic decomposition of *organic compounds.* It is the major component of natural gas used in the home and is an important *greenhouse gas.*

MIACC: Major Industrial Accidents Council of Canada.

Monoculture: Agriculture that is based on a single type of crop.

Morbidity and **mortality:** Medical terms that refer to illness and death, respectively.

NAAQOs: National ambient air quality objectives.

NAFO: Northwest Atlantic Fisheries Organization.

Natural background concentrations: The expected concentrations of substances in the *environment* in the absence of human influence.

Natural selection: The mechanism for evolutionary change in which individual organisms in a single *population* die off over time because they cannot tolerate a new stress and are replaced by individuals whose genetic traits allow them to cope with the stress and to pass these adaptive traits on to their offspring (Miller 1985).

NAPS: National Air Pollution Surveillance network.

NAWMP: North American Waterfowl Management Plan.

Net undercoverage: The difference between *undercoverage* and *overcoverage.*

NGOs: Non-governmental organizations.

Nitrogen oxides (NO_x)**:** Air pollutants that consist primarily of nitric oxide (NO) and nitrogen dioxide (NO_2) produced by the reaction of nitrogen (N_2) and oxygen (O_2) in air at high temperatures in internal combustion engines and furnaces (Miller 1985).

NO: Nitric oxide.

NO_2: Nitrogen dioxide.

NO_3^-: Nitrate.

NO_x: *Nitrogen oxides.*

N_2O: Nitrous oxide.

Non-renewable resources: Natural resources that can be used up completely or else used up to such a degree that it is economically impractical to obtain any more of them (e.g., coal, crude oil, metal ores). (Compare *renewable resources.)*

NPRI (National Pollutant Release Inventory)**:** A company-specific database of information on releases of a wide range of substances, many *toxic*, from business facilities in Canada. Environment Canada is the responsible agency.

NRTEE: National Round Table on the Environment and the Economy.

Nutrient cycles: The movement of nutrients through an *ecosystem* and its organisms.

O_3: *Ozone.*

ODS: *Ozone-depleting substance.*

OECD: Organisation for Economic Co-operation and Development.

Operating expenditures (by business)**:** Business expenditures on labour (wages and salaries), purchase of fuel and electricity, materials and supplies, excluding *capital* goods and services.

Organic compounds: Compounds based on carbon and usually also containing hydrogen, with or without oxygen, nitrogen, or other elements (Wells and Rolston 1991). Organic originally meant 'of plant or animal origin,' and it is still sometimes used in this way. For example, 'organic waste' can mean food scraps, manure, sewage, leaves, etc.; 'organic fertilizer' can mean manure; 'organic deposits' can mean *peat* or other plant material in soil; 'organic nutrients' can mean nutrients derived from decayed plant material. However, now that organic compounds are routinely created by people, the word 'organic' is also used to refer to synthetic organic compounds, as in 'organic *pollution*' (which can include *toxic* human-made organic compounds).

Organic matter: Organic matter in soils is composed of decaying plant and animal remains. In general, it improves soil structure and helps soils retain water and nutrients.

Organochlorine compounds: A group of molecules that are composed of carbon, hydrogen, oxygen and chlorine atoms. These are generally synthetic compounds, such as *PCBs*, *dioxins* and some *pesticides*.

Overcoverage: The number of persons who should not have been counted in the census or who were counted more than once.

Ozone (O_3)**:** A pungent, faintly bluish gas composed of three atoms of the element oxygen. In the lower 10 kilometres of the *atmosphere*, it occurs as a *pollution* product formed by combining *nitrogen oxides* (NO_x) and *volatile organic compounds* (VOCs) in the presence of sunlight. In this portion of the atmosphere, it is also a *greenhouse gas*. Above 20 kilometres, it is produced naturally and serves to protect life on earth from damaging *ultraviolet radiation*. See also *ground-level ozone* and *stratospheric ozone*.

Ozone-depleting substances (ODS)**:** Certain chlorine and/or bromine compounds (*chlorofluorocarbons* or halons) that break down when they reach the *stratosphere* and then destroy *ozone* molecules.

Ozone hole: A thinning in the *stratospheric ozone layer*. Designation of an "ozone hole" is made when the detected amount of depletion exceeds 50%. Seasonal ozone holes have been observed over both the Antarctic and Arctic regions, part of Canada, and the extreme northeastern United States.

Ozone layer: Layer of gaseous *ozone* (O_3) in the upper *atmosphere* that protects life on earth by filtering out harmful *ultraviolet radiation* from the sun (Miller 1985).

PAC: Pollution abatement and control.

Parasite: An organism that consumes part of the blood or tissues of its *host*, usually without killing the host (Ricklefs 1990).

Particulate: Anything that can be filtered from the air. Large particles, such as road dust or pollen, can irritate the eyes, whereas smaller particles (often called 'fine particulates') from smoke and fumes can be inhaled into the lungs.

Pathogen: Disease-causing organisms such as *bacteria*, *viruses* and *parasites*.

PCBs (polychlorinated biphenyls)**:** A group of at least 50 human-made, industrial *organochlorine* chemicals. Because they do not conduct electricity, PCBs began to be widely used as insulators in the 1930s. They do not break down easily in the environment and there is concern that they may be harmful to *biota*. Some kinds of PCBs are thought to cause cancer and may contribute to other subtle effects in unborn children. The use of PCBs was banned in many countries, including Canada, in the 1970s.

PCDDs and **PCDFs:** see *Dioxins and furans*.

PFCs: Perfluorocarbons.

Peat: A type of soil where the production of plant materials exceeds decomposition.

Pelagic: Pertaining to organisms that swim or drift in a sea or lake, as distinct from those that live on the bottom (*Concise Science Dictionary* 1984). Includes plankton, many fish species, and oceanic birds.

Permafrost: Perennially frozen layer in the soil, found in alpine, arctic and antarctic regions.

Persistent organic pollutants (POPs)**:** Chemical compounds that do not break down easily in *ecosystems*. They can be transported long distances in the *atmosphere* and can biomagnify in *food chains*. Most POPs are human-made, and many are *organochlorines*.

Pesticide: A substance, usually a man-made chemical, used to kill unwanted plants and animals. Includes herbicides, insecticides, algicides and fungicides.

PERT: Pilot Emission Reduction Trading.

Photosynthesis: The manufacture by plants of carbohydrates and oxygen from *carbon dioxide* mediated by chlorophyll in the presence of sunlight.

PM_{10}: Particulate matter smaller than 10 micrometers in diameter.

$PM_{2.5}$: Particulate matter smaller than 2.5 micrometers in diameter.

Pollution: Undesirable change in the physical, chemical or biological characteristics of the air, water or land that can harmfully affect the health, survival or activities of humans or other living organisms (Miller 1985).

POPs: *Persistent organic pollutants.*

Population: In biology, a group of organisms of the same species living within a specified region (Wells and Rolston 1991).

Primary energy source: An energy source that is either consumed directly in the form in which it is produced or converted into secondary energy sources and then consumed. The primary energy sources used in Canada are coal, crude oil, natural gas and its associated liquids (ethane, butane, propane and pentanes plus), hydro and other renewable electricity, and nuclear electricity.

R&D: Research and development.

Radiation: The propagation of energy through matter and space in the form of fast-moving particles (particulate radiation) or waves (electromagnetic radiation) (Miller 1985).

Radioactive: Describes substances or objects that emit *radiation* (Miller 1985).

Radioactive waste: The *radioactive* end products of nuclear power plants, research, medicine, weapons production or other processes involving nuclear reactions (Miller 1985).

Radioisotope: An isotope of an element that is radioactive. For example, carbon-13 is a radioisotope of the normally non-radioactive element carbon. Radioisotopes have many applications, including as diagnostic and therapeutic agents in medicine. Many radioisotopes are very long lived and can have negative effects on humans and animals when released into the *environment.*

Radon: A *radioactive* gas formed by the radioactive decay of radium.

Rainshadow: The dry area on the leeward side of a mountain range.

Recruitment: The addition of new individuals to a *population* by reproduction, often restricted to the addition of breeding individuals (Ricklefs 1990).

Recycling: The collection and treatment of waste materials so they can be used again, as when used glass bottles are collected, melted down and made into new glass bottles (adapted from Miller 1985). (Compare *reuse.*)

RENEW: Recovery of Nationally Endangered Wildlife Committee.

Renewable resource: A resource that potentially cannot be used up because it is constantly or cyclically replenished. Either it comes from an essentially inexhaustible source (such as solar energy), or it can be renewed by natural or human-devised cyclical processes if it is not used faster than it is renewed (Miller 1985). (Compare *nonrenewable resource.*)

Reuse: The use of a product over and over again in the same form, as is done with returnable glass bottles, which are washed and refilled (Miller 1985). (Compare *recycling.*)

Roundwood: Sections of tree stems with or without bark. May include logs, bolts, posts and pilings (Haddon 1988).

Run-off: 1) The amount of precipitation appearing in surface streams, rivers and lakes; defined as the depth to which a drainage area would be covered if all the run-off for a given period of time were uniformly distributed over it. 2) That part of precipitation, snow melt or irrigation water that runs off the land into streams or other *surface water.* It can carry pollutants from the air and land into receiving waters.

S&T: Science and technology.

Saturated zone: The subsurface zone below the *water table* in which pores are completed filled with water. Water in this zone is called *groundwater.*

Sediment: Fragmented organic or inorganic material derived from the weathering of soil, alluvial and rock materials. It is removed by *erosion* and transported by water, wind, ice and gravity.

Sedimentation: The deposition of *sediment* from a state of suspension in water or air.

Shellfish: Aquatic shelled molluscs (e.g., oysters) and crustaceans (e.g., crabs, shrimp) (Allen 1990).

Silviculture: The management of forest land for timber.

Smog: Literally a contraction of ‘smoke’ and ‘fog’; smog includes *ground-level ozone* and numerous other *contaminants.* It tends to provide a brownish-yellow haze to the *atmosphere*, especially over urban areas.

SO_2: Sulphur dioxide.

SO_4^-: Sulphate ion.

SO_x: *Sulphur oxides.*

Soil amendment: Natural and synthetic substances applied to soil to increase fertility, improve structure or balance acidity. Examples include rock phosphate, manure and ground limestone (lime).

Solid waste: Any unwanted or discarded material that is not a liquid or a gas (Miller 1985).

Solvent: A substance (usually liquid) capable of dissolving or dispersing one or more other substances.

Stratosphere: The layer of the *atmosphere* between about 10 and 50 kilometres above the earth’s surface within which temperatures rise with increasing altitude. Contains *stratospheric ozone*, which absorbs potentially harmful *ultraviolet radiation.*

Stratospheric ozone: In the *stratosphere*, solar *radiation* converts some oxygen molecules (O_2) into *ozone* (O_3). Ozone absorbs much of the sun's potentially harmful *ultraviolet radiation* and prevents it from reaching the earth (adapted from Arms 1990).

Streamflow: The discharge that occurs in a natural channel. Although the term 'discharge' can be applied to the flow of a canal, the word 'streamflow' uniquely describes the discharge in a surface stream course. The term 'streamflow' is more general than the term *'run-off'*, and may be applied to discharge whether or not it is affected by diversion or regulation.

Sulphur oxides (SO_x)**:** A group of gases, mainly sulphur dioxide (SO_2), released by the combustion of *fossil fuels* and by natural sources such as volcanoes. Sulphur dioxide, a colourless gas with a pungent odour, irritates the upper respiratory tract in humans and leads to *acidic deposition*.

Surface water: Water on the earth's surface exposed to the *atmosphere* (e.g., rivers, lakes, streams, ponds, reservoirs, etc.).

TAC: Total allowable catch.

Tailings: Waste rock rejected after most of the recoverable valuable minerals have been extracted (Whiteway 1990). Tailings are generally finely ground rock particles that are transported as a water slurry to a storage area, known as a tailings pond, at the mine site. Usually the tailings composition is similar to the parent ore body and may therefore contain metals, sulphides, salts or *radioactive* materials.

Temperate forest: One of the three main forest types in the world, composed mainly of deciduous trees. The other two types are the northern (boreal), largely evergreen forest and the tropical evergreen forest.

Thermal power: Electric power generated using heat from the combustion of *fossil fuels* or from nuclear fission.

Tillage: Ploughing or other means of cultivation intended to prepare land for crops or control weeds.

Total suspended solids (TSS)**:** A measure of the suspended solids in *wastewater*, *effluent* or water bodies. Suspended solids are small particles of solid pollutants that float on the surface of, or are suspended in, sewage or other liquids.

Toxic: Harmful to living organisms.

Transpiration: The process by which water vapour escapes from living plants, principally through the leaves, and enters the *atmosphere*.

Tributary: A stream that contributes its water to another stream or body of water.

TSMP: Toxic Substances Management Policy.

TSS: *Total suspended solids.*

Tsunami: A Japanese term which has been adopted to describe a large, seismically generated sea wave that is capable of considerable destruction in coastal areas.

Ultraviolet (UV) **radiation:** *Radiation* from the sun that can be useful or potentially harmful. UV-A rays, from one part of the spectrum, enhance plant life. UV-B rays, from other parts of the spectrum, can cause skin cancer or other tissue damage. The *ozone layer* in the *atmosphere* partly shields us from ultraviolet rays reaching the earth's surface.

Undercoverage: The number of persons who were expected to have been enumerated in a census but were not.

Unsaturated zone: The subsurface zone above the *water table* in which pore spaces are only partially filled with water. Water in this zone is called soil moisture.

UV: *Ultraviolet.*

VCR: Voluntary Challenge and Registry.

Virulent: Poisonous or disease-causing.

Virus: A small package of RNA or DNA that reproduces only in living cells, using the *host* cell's mechanisms and nutrients. Viruses often cause diseases.

VOC: *Volatile organic compound.*

Volatile organic compound (VOC)**:** Any *organic compound* that has a high tendency to pass from the solid or liquid state to the vapour state under typical environmental conditions. Such compounds participate in a range of processes that lead to atmospheric pollution, including the formation of urban *smog*.

Wastewater: Water that carries wastes from human activities, either directly into a receiving water body or to a wastewater treatment plant.

Water table: The subsurface level marking the boundary between the lower *saturated zone* and the upper, *unsaturated zone*.

Watershed: *Drainage basin.*

WCED: World Commission on Environment and Development.

Wet sulphate deposition: Occurs when rain, snow or fog carries sulphate from the air to the earth's surface. It is a component of *acidic deposition*.

Wetlands: Lands where water saturation is the dominant factor determining the nature of soil development and the types of plant and animal communities living in the surrounding *environment*.

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The letter 'n' following a page number indicates a note (e.g., '101n1' refers to note 1 on page 101).

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GDP = Gross Domestic Product
PAC = pollution abatement and control
R&D = research and development

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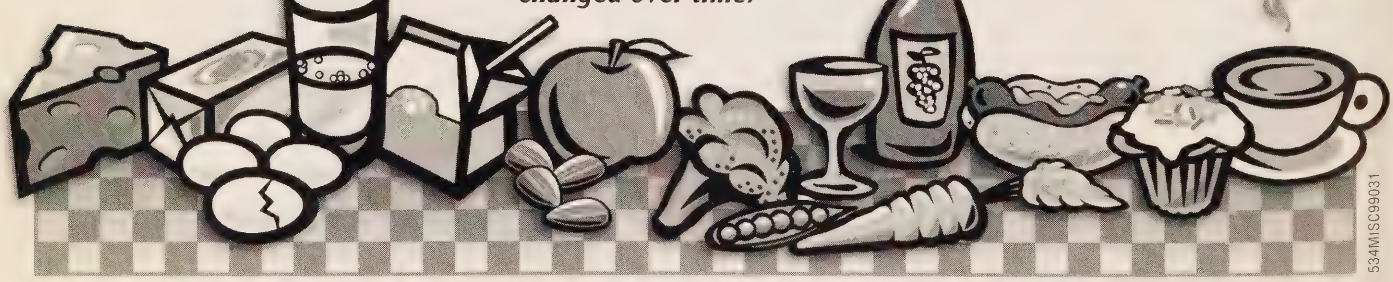

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